UNIVERSITY OF OSLO
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Diffusion of innovation and user acceptance of tickets

An empirical study in an ubiquitous computing context

Master thesis
30 credits

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Foreword

This thesis is the result of a work project that constitutes the practical part of the Master's degree offered by the Information System group at the Department of Informatics, University of Oslo, Norway. The Master's degree consists of a theoretical and a practical part. The theoretical part consists of 90 study points which equals one and a half year with full study. The practical part consists of a research project which corresponds to 30 study points and this project was performed under the guidance from an internal advisor.

I would like to thank my internal supervisor Jo Herstad at the Department of Informatics for motivating and interesting meetings. I would also like to thank my friends Andreas, Jørgen, Mads, Audun, Kim and Øystein for comments on my ideas and my girlfriend Heidi and my family who supported me greatly all through the project. Last, but not least a special thank to Øivind who proofread the whole thesis.

Abstract

This thesis lies within the field of Information Systems and Human-Computer Interaction with a particular focus on user acceptance of tickets in relation with football games. The goal of this thesis is to study user acceptance of paper and electronic tickets and to study the electronic ticket in relation with the Innovation of Diffusion theory (IDT) by Rogers (Rogers, 2003) and Ubiquitous computing and related theories. The technology emphasized is the wireless technology RFID and especially contactless smart cards which are used as the electronic ticket. A case study is conducted on the Smart Stadium system which is used at different football stadiums in Norway. Kristiansand stadium is one of these and it is reviewed closely. One of the benefits with the Smart Stadium system is the use of electronic tickets. A user survey is conducted among 156 users of the system as well and this shows that the paper ticket has higher user acceptance than the electronic ticket. Tradition and the feeling of security when holding the paper ticket physically in the hand are the mains reasons for this choice. The categorization of the respondents from the survey into adopter categories shows slight differences from the original model developed by Rogers. In addition can concepts from Ubiquitous computing and related theories like Calm computing, Tangible computing, Ambient Intelligence and Unremarkable computing make the attribute of complexity, which is one of Rogers five perceived attributes of accepting technology, better described and understood.

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1 Introduction

This chapter contains a short introduction to this thesis in which background, focus, motivation and problem definition of this thesis will be set. At last an overview of the structure will be presented.

1.1 Motivation and background

Most people may not even realize it, but Radio Frequency Identification (RFID) has become an integral part of our lives. After nearly sixty years of development at least hundreds if not to say thousands of applications have emerged. RFID is used to collect tolls without stopping, entrance cards for buildings, automatic tracking of cars and merchandise to prevent theft, buying goods from dispensers, tracking books in the library, passports, washing machines, buying hamburgers and more (Landt, 2005). Supply chain management with tracking of goods from the factory through the distribution centre and to the store has emerged as an application domain with large opportunities since RFID tags are seen as better barcodes than the optical ones (Almnes et al., 2005). RFID has received a lot of attention both in media and research the last couple of years and this is due to several reasons, but the main cause being that large corporations like the U.S. Department of Defence (DoD) and Wal-Mart are trying to use RFID as a tool for keeping a closer eye on their supply chains (Juels, 2006).

RFID is a technology which will become more and more popular and widespread and the curiosity about this technology motivated me to study it. In addition football has always interested me and after hearing the news about the use of RFID-based electronic tickets in relation with the World Cup held in Germany this summer (RFIDNews.org, 2006), the phenomenon and the technology to be studied were obvious. The Smart Stadium system developed in the UK is a great opportunity to study the appliance of the RFID technology and the use of electronic tickets. Since football is the largest sport in Norway and the ticket system is used at six Norwegian football stadiums, the technology has affected many users. The interaction between the machine and the human is in the centre of this thesis as the preferred choice of ticket, reasons for this choice, adopter categories and ease of use of the RFID-based electronic tickets are investigated closely.

1.2 Focus

This thesis lies within the field of Information Systems (IS) and Human-Computer Interaction with a particular focus on user acceptance of tickets in relation with football games. The goal of this thesis is to study user acceptance of paper and electronic tickets and study the electronic ticket in relation with the Innovation of Diffusion theory (IDT) by Rogers (Rogers, 2003) and Ubiquitous computing and

related theories. The technology emphasized is the wireless technology RFID and especially contactless smart cards which are used as the electronic ticket.

This thesis has focus on the Smart Stadium and Venue Solution developed by Fortress GB (FortressGB.com, 2006a) in UK which is a complete solution based on RFID for venues and was developed in cooperation with the English football clubs Manchester City and Liverpool FC. Fortress GB's Smart FC solution uses a contactless smart card based on RFID and applications such as access control, loyalty, electronic money and tickets are integrated on this smart card. The whole idea behind the solution was to develop a system which can cut costs and make the stadiums run more efficiently because there is no secret that football is business and every club wants to make as large profit as possible, but at the same time offer a good service and experience to the fans. By using the system people can gain access to the stadiums at a faster pace than before, but also take advantage of the other offers integrated on the smart card. In Norway there are currently six clubs using or on the verge on using the Smart Stadium system and these are IK Start, Sandefjord Fotball, Ålesund FK, Viking FK, Lillestrøm SK and Brann SK. I will look at what is the preferred choice of ticket between the paper ticket and the RFID-based electronic ticket and the reasons for this choice. Ease of use of electronic tickets will also be studied. A user survey is conducted in this occasion among the people who attend the home games of the clubs which employ the Smart Stadium system.

1.3 Problem area

The 8th of May the RFID Innovationcenter AS was opened in Oslo. It is a cooperation between different companies like SINTEF, Den Norske Emballasjeforeningen, GS1, Dataforeningen og HSH. The Innovationcenter is meant to be the preferred Norwegian center for development and testing of RFID- solutions (RFIDLab.no, 2006). Norway has always been leading when it comes to the use of new technology and RFID is a relative new technology even though a similar technology was used under the second world war to identify aircrafts as friends or foe (Landt, 2005). During the opening of the Innovationcenter, there were examples shown of merchandise on a rollenband where a RFID reader interrogated the tag on the merchandise for information and showed this information on a screen. The potential for RFID is big and in Norway RFID has been deployed in several areas like for example in electronic tickets. RFID is an Ubiquitous technology as it is present everywhere and around us and the notion of Ubiquitous computing was first introduced by Mark Weiser in his article "The Computer for the 21st Century (Weiser, 1999). Ubiquitous computing is a computing paradigm and the third through the history and has led to the development of other related theories like Calm computing (Weiser and Brown, 1997) and Unremarkable computing (Tolmie et al., 2002). Weiser's vision of the computer for the 21st century was for the computers to vanish into the periphery of attention and the humans to be in the centre of attention. The use of the electronic tickets is by some people described exactly this way to either be in the centre of attention or in the periphery.

RFID-based electronic tickets are a fairly new phenomenon in Norway. A few football stadiums have started employing them and the New Ticket and Payment system project by the public transport, AS Oslo Sporveier, is another example. The change from the traditional paper ticket to the electronic will affect many users and their acceptance. To better understand how this new innovation will diffuse and what type of people will take use of the innovation, IDT is a helpful theory.

The use of digital technology as RFID in ticketing systems raises several important issues which can be studied. Privacy, user acceptance, trust and how the users experience and perceive the technology are just a few examples. In this thesis the following topics are studied:

- User acceptance
- RFID-based electronic ticket and paper based tickets
- Innovation of diffusion theory
- Ubiquitous computing

1.4 Problem definition

After describing the problem area in the previous section, the following problem definition has been taken:

- *What is the preferred choice of ticket today between the paper and the RFID-based electronic ticket and what are the reasons for this choice?*

At the football stadiums using the Smart Stadium system people have the choice between the RFID-based electronic ticket and the paper ticket. The electronic ticket has only been employed for a few years, but has gained a lot of acceptance among the users, but there exists no studies which show which type of ticket is the preferred one and which type of reasons are the basis for this choice.

The underlying questions in this problem definition are:

- *Categorize the respondents of the questionnaire after the model of adopter categorization developed by Everett Rogers.*

- *Discuss the perceived attribute of complexity by using concepts from Ubiquitous computing and related theories.*

People take use of new innovations like the RFID-based electronic ticket at different points in time. Some are fast and start using it as soon as it arrives, while others are sceptic and seek advice among friends, colleagues and family before employing it. Users of an innovation can be categorized after different characteristics and a model of adopter categorization is created by Rogers. The answers from the user survey will be categorized after this model.

Rogers has defined five perceived attributes of accepting technology in IDT and complexity deals with the ease of use and the understanding of an innovation which in this thesis is the electronic ticket. Ubiquitous computing and theories as Calm computing, Ambient Intelligence, Unremarkable computing and Tangible computing have developed concepts which are suited for discussing ease of use of a technology.

1.5 Overview of the chapters

- **Chapter 1: Introduction**

This chapter contains a short introduction to this thesis, in which background, focus, motivation and problem definition of this thesis will be set. At last an overview of the structure will be presented.

- **Chapter 2: Methodology**

This chapter will both describe what quantitative and qualitative research are together with a description of some of the existing research methods like interview, observation and survey. In addition there will be an explanation and description of the methods I used in my research in order to answer the problem definition.

- **Chapter 3: Theoretical approach**

This chapter will be divided in two main parts. The first part will try to place this thesis in a framework where Ubiquitous computing is central and main concepts will be developed and used later on in the discussion with the findings from my empirical investigation. There exists several definitions of the word Ubiquitous, but they are mostly similar. The Oxford dictionary says that: "Ubiquity is the ability to be present everywhere or at several places at once. The term is derived from Latin ubique which means everywhere" (Hornby et al., 2000). What follows from this definition is that RFID is an Ubiquitous technology as it is present everywhere and around us.

The second part will look further into the notions of user, technology, user acceptance and the innovation of diffusion theory. The focus of this thesis is on a new ticket system based on RFID which is used on football arenas around Europe and how users perceive and experience this technology and why they choose paper or electronic tickets.

- **Chapter 4: Technical focus - RFID**

This chapter is about the RFID technology, how it works, the history and an overview of application areas.

- **Chapter 5: Case study**

This chapter will present the Smart Stadium solution, which is developed and implemented by Fortress GB and Buysec AS., together with a review of Kristiansand stadium which has implemented some of the features of the system.

- **Chapter 6: Findings**

This chapter will present the results from the conducted empirical studies.

- **Chapter 7: Discussion**

This chapter will repeat and discuss the problem definitions introduced in chapter 1.5. In order to discuss the research questions, theory and concepts from chapter 3 will be used together with the findings from the empirical investigation which were presented in chapter 6. The research questions concern user acceptance of tickets, adopter categorization of users and the perceived attribute of complexity which deals with the ease of use and the understanding of technology.

- **Chapter 8: Conclusions**

This chapter will conclude the thesis by bringing forward the research questions from the chapter of introduction and explain which research methods were used in order to answer these. Suggestions for further work will be given as well to encourage other researchers to explore the research area of user acceptance and diffusion of innovation theory in relation to tickets even further.

2 Methodology

This chapter will both describe what quantitative and qualitative research are together with a description of some of the existing research methods like interview, observation and survey. In addition there will be an explanation and description of the methods I used in my research in order to answer the problem definition.

2.1 Literature Studies

A review of literature helps researchers in the way that they limit the scope of the inquiry as well as showing the readers why a certain topic is important. The literature review also fulfils several other purposes. One of them is that the review shares results from other studies which are closely related to the one being studied. Another is that the review relates a study to an already ongoing discussion in literature about a certain topic, filling in gaps which are missing, but also extends prior studies. Related studies are often conducted by scholars and researchers and are best found in journals and books which are usually located in the library. Internet is otherwise a good resource for locating articles (Creswell, 2003).

There are different types of literature reviews depending on the type of research conducted. Qualitative research usually has three different locations for placing the literature in a scientific paper. The first possibility is to include the review in the introduction to a study. This way the literature imposes a kind of frame by telling who has been writing about a topic, who has studied it and who has indicated the importance of the topic. The second opportunity is to have the literature review in a separate section or chapter and this is typically done in quantitative research. The third possibility is to place the literature at the end of the study and make it a basis for comparison. The findings in previous research are then compared to findings in the present study. In quantitative research it is normal to provide a chapter of literature review at the beginning of a study to point out a direction for the questions the researcher wants to the find the answers to. In addition it is common to include theory at the end of the study to compare this with the results from the current study. A third type of research is a mixed methods study where the researcher combines both quantitative and qualitative research methods. The placement of the literature is then depending on what type of mixed methods design which is being used (Creswell, 2003).

Umberto Eco has written a book about how to prepare and write for a PhD. The book is also very helpful for students doing their master thesis and has become very popular first of all in Italy, but is now spreading to other countries as well. It has been implied that it is a kind of cheating to read the book when working on a master thesis. Eco comes with good advice on how to conduct a good literature search and review. One of the suggestions is to first write a table of contents before starting the search for literature. This way the researcher knows what to look for when conducting the search. Literature with references will be added in the table of contents under the right chapter as soon as it is discovered (Eco, 2002).

2.2 Qualitative methods

Every book or text on qualitative methods usually begins with a definition about what qualitative method is or what it is not. There are many different descriptions found, but largely there is a consensus regarding the term. Denzin and Lincoln (Denzin and Lincoln, 2000) have the following definition:

> "Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that makes the world visible. These practices … turn the world into a series of representations including fieldnotes, interviews, conversations, photographs, recordings and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural setting, attempting to make sense of or to interpret phenomena in terms of meanings people bring to them."

This definition clearly states many of the important points of qualitative research. People's behaviour, actions and beliefs are studied in a natural setting and data can be collected using for example observation, interviews or ethnography. Spencer and Snape (Ritchie and Lewis, 2003) explained the use of qualitative methods this way:

> "Qualitative methods are used to address research questions that require explanation or understanding of social phenomena and their contexts. They are particularly well suited to exploring issues that hold some complexity and to studying processes that occur over time."

2.2.1 Interview

In qualitative research in-depth or unstructured interviews are one of the most important methods for collecting data. By talking to people it is easier to understand their point of view and follow-up questions can be asked directly. The interview can be seen as a social interaction between two persons and it is sometimes referred to as a kind of conversation even though there are obvious differences between an interview and a conversation (Ritchie and Lewis, 2003).

There are several ways to conduct an interview. One way is the completely unstructured interview where the researcher only has a topic to ask about, but none of the questions are prepared in advance. The questions are instead made up as the interview moves along. Another possibility is the semi-structured interview where a relative open framework is provided where some of the questions are written in advance, but the majority is created during the interview. The researcher is mostly guided by an interview guide. The third possibility is to conduct a structured or standardized interview where a combination of open-ended and close-ended questions is used (Bailey, 1987).

It takes time and effort to come up with open questions during the interview even though it sounds easy. It is a habit among people to ask closed questions where the answer is simply no or yes, but the goal is to ask broad questions in order to receive detailed answers. Using what, where, why or how normally gives a good question. A pitfall when interviewing is asking leading questions which causes the respondent to answer in a way which is desired by the interviewer. This should be avoided as this causes bias of the collected data (Ritchie and Lewis, 2003).

2.2.2 Observation

When a researcher wants to collect data on nonverbal behaviour, the observational method is the most preferred technique and it can be used everywhere in for example schools, hospitals, and police stations. Observation is useful when the researcher wants to have a comprehensive and in-depth picture of behaviour. The most common sense to use is the eyes, but it is also possible to include hearing, touch and smell to collect data. Surveys are often conducted after observations have been performed. A researcher may be unaware of certain aspects of a phenomenon, but by observing in advance before conducting the survey, the researcher may learn of unexpected behaviour which to ask for in the survey (Bailey, 1987).

There are four types of observations which can be performed. Conducting observation in a natural setting is the most preferred way, but it is also possible to use a laboratory setting where the environment is fixed according to the researcher's preferences. In a natural setting like at a stadium, at a school or in a hospital, the researcher has no influence on the environment. In addition there are two different types of structure which can be imposed which are structured and unstructured observation. Structured observation is for example counting the number of times a behaviour occurs or an expression is said while in unstructured observation, the researcher does not look for anything particular, but only observes and writes down everything of interest (Bailey, 1987).

As with all research methods, there are some advantages and disadvantages with the observational method. One of the advantages is the possibility to conduct the observation in the subject's natural setting and environment. In comparison to making an interview where the respondent has to take time off from his or her schedule, observation can be conducted over a longer period of time and thereby observe trends. Another advantage is the possibility to study the respondent as a whole instead of using the survey which is a limited instrument only concerned with parts of the individual. Lack of control, difficulties of quantification and gaining entry are some disadvantages with the observational method. Lack of control is in relation with the natural setting where the researcher has little influence over variables which may affect the data. With regards to quantification, the observer usually records everything and makes a scale afterwards to measure the data, but observation yields a lot of data which can be difficult to categorize compared to surveys which have scales prepared in advance. When conducting observation in a natural setting it may be difficult to receive approval and gain entry for the study.

The people you study can be suspicious of your activities and behave in other ways than they normally do (Bailey, 1987).

2.3 Quantitative methods

Quantitative methods are concerned with numbers and use methods which result in numerical data, statistics and graphs. In addition to surveys, experimental design is often used in quantitative research. When conducting surveys, close-ended questions are used in order to be able to collect data to measure (Creswell, 2003).

2.3.1 Questionnaire

A survey or questionnaire consists of several questions asked to a hopefully representative section of the population at a single point in time (Bailey, 1987). Trends, attitudes or opinions of a sample of a population is studied and described in a numerical fashion. The researcher generalizes about the population from the results of the study (Creswell, 2003). The persons who answer the questions are called survey respondents and the survey can be completed in several ways. The questions can be asked by an interviewer in a natural setting, asked over the telephone, handed out in a classroom or sent to people by email. The reason for conducting a survey of a sample of a population is because it would take too much time to interview everyone (Bailey, 1987).

There are two types of questions to be asked depending on what the researcher wants for answers. Close-ended questions have fixed alternatives which let the respondent choose one or more of the provided options. The questions are easy to understand and the respondents will thus answer the "don't know" category fewer times. This is just one of the advantages. Another is that the answers are standard and therefore makes them easy to compare from one person to another. The disadvantage of closed-ended questions is the opportunity for a person to try to guess the right answer if he or she does in fact not have an answer or opinion. Open-ended questions have no fixed categories of answers, but it is up to the respondent to provide with an appropriate answer. This type of question is often used when asking for opinions and the respondent can answer with all the details he or she wants to clarify. Another advantage is the possibility to ask complex questions which are too hard to fit into predefined categories, but this can make people disregard the questions and thereby giving no useful data to the researcher. It is also possible to mix open-ended and close-ended questions in a survey and when conducting this type of survey, it is best to start with easy and close-ended questions first before introducing open-ended questions. The first questions should be interesting ones in order to stimulate the respondent to continue the survey. When people face complex or sensitive open-ended questions in the beginning of the survey, they can refuse to answer and disregard the whole survey. If this type of question is introduced later on and ignored, at least the answers from the close-ended questions are saved and can

be used. The order of the questions does matter and a researcher will obtain more complete questionnaires when following the mentioned simple rules (Bailey, 1987).

The final preparation before mailing the questionnaire to the respondents is the pre-test and this should be conducted in the same manner as the final study. If the study is conducted by interviews, the pre-test should be interviews and if the study is a mailed questionnaire, the pre-test should be mailed. The point of the test is to detect confusing, missing or inappropriate questions, poor scales of measurement or any other aspect which may be relevant. After the pre-test is complete, the questionnaire needs to be revised and yet another pre-test should be conducted (Bailey, 1987).

There are many advantages and disadvantages when using mailed questionnaires. First of all is the benefit with saved money and time. Recruiting competent people to conduct interviews are expensive and it takes much time. Expenses from $15 to $30 are not uncommon nowadays while mailed questionnaires only have the cost of the stamp and the printed paper. When mailing the questionnaires, all can be sent at the same time and most of the replies will come within a week while interviews can take up to several months to complete. Anonymity is assured because there is no interviewer present to identify the respondent later on, but also no bias is assured in the absence of an interviewer. However there is a lack of flexibility because there is no one there to answer questions from the respondent if he/she feels uncertain about a part of the questionnaire. The rate of completion is very high when conducting interviews, but mailed questionnaires often reach a low response rate which may be as low as 50%. Of those 50% maybe only 10% is considered good enough by the researcher to be used (Bailey, 1987).

2.4 Mixed Methods

Mixed methods are a third type of research which is relatively new in social and human sciences. The research uses a combination of quantitative and qualitative methods and there are six different models. Concurrent triangulation strategy is the most known and used one (Creswell, 2003).

2.4.1 Concurrent Triangulation Strategy

This model is used when the researcher wants to use one or more of both types of research to try to confirm or corroborate findings in a single study. The main point is to balance the weaknesses and the strengths of the different methods. The data collection occur concurrent and thus saves time since the collection can be finished in one phase rather in two sequential ones. Usually the researcher gives priority to either the qualitative or quantitative method, but ideally the priority would be equal between the two. As a result of the triangulation strategy, the claims from the study can either be strong or weak depending on the corroborating findings (Creswell, 2003).

In addition to being a good and advantageous model since most researchers are familiar with it, the model also has some disadvantageous like for example the difficulty of comparing the results from two different methods as well as the expertise which is needed to study a case or phenomenon with two different research methods (Creswell, 2003).

2.5 Applied methods

2.5.1 Questionnaire

In order to answer the research problem of this study, a survey was conducted to get a deeper understanding of why people choose to buy electronic or paper tickets and what the users feel about the ticket system which is used at some of the arenas in Norway's top two divisions in football for men (Appendix I contains the questions). The questionnaire consisted of both open-ended and close-ended questions and it started with a few easy close-ended questions in order to stimulate the respondents to continue the survey.

Interviews could be conducted, but this takes a lot of time and money and it is not easy to collect information from a large sample of the population. The five clubs which use the ticket system today (Lillestrøm SK, Ålesund FK, IK Start, Sandefjord Fotball and Viking FK) have stadium capacity which exceeds 50.000 people in total and to reach as many of the spectators as possible, a survey was prepared. Lillestrøm was left out because they only use electronic tickets in the VIP section of the stadium. Questions in relevance to the problem definition were made and after the survey was complete, a pretest was performed. I made a web-survey and sent it to some of my friends who like football to look over the questions and see if any of them were unclear or ambiguous. The questions were corrected and then I tried to get in contact with the webadministrator of Ålesund FK by email. I wanted him to make a news flash about the survey on the homepage, but I never got any response. Instead the link was posted on the forum to the club. After the first 30 replies, I looked through the answers to see if I received the information I was after or if something needed to be changed. After the revision was complete, the survey was ready to be released in full scale.

2.5.1.1 Population and sample

Emails were sent to the administrators of the homepages of the other mentioned clubs in hope of getting them to post a news about my master thesis and a link to the survey, but no response either negative or positive were received. The forums were once again used and the response rate the first couple of days were good, but slowly became lower and lower. In addition I sent email to the person responsible for the home games of Sandefjord FK and asked for permission to hand out questionnaires outside of the arena, but they had already performed a similar type of investigation

two home games in a row and therefore permission was denied. I then replied twice to ask if I could see the results of their research or see the data, but nothing happened. Permission to hand out the questionnaire was also sent to Start and this turned out positive. I was added to the list of workers for the game and had free access to the whole stadium. I went to a home game of Sandefjord and IK Start in order to reach out to even more people than the ones using the forums and a goal was set to at least 200 responses. When conducting questionnaires the response rate tends to be low and among the responses received, there are always some which cannot be used. In the end after two weeks of data collection I received a total of 201 and of them 156 could be used. This meant that 77.6% of the responses were adequate.

2.5.1.2 Instrumentation

The instrumentation used for the questionnaire was self-made. The programming language Python was used to create a cgi-script and an html form with the questions. When the respondent filled out the survey correctly and sent it, an xml-file of the answers was created and saved, but an email also notified me with the results. There are many instrumentations which could be used like Uio's nettskjema (UiO.no, 2006) and Unit Command Climate Assessment and Survey System (Holmes, 2004) which is a web-based survey script written in PHP. The decision to create my own survey was based on the need to combine close-ended and open-ended questions.

2.5.2 Observation

Observation is most commonly performed before the survey, but since my research used the model of concurrent triangulation strategy, observation was conducted in the same period as the survey was online. I wanted to observe the ease of use of both paper and electronic tickets in order to collect data on nonverbal behaviour and therefore attended two games. The first game was Sandefjord against Vålerengen IF at Storstadion in Sandefjord and the second was Start against Odd at Kristiansand stadium in Kristiansand (chapter 5.1.3). At both occasions, after I entered, I stood by the entrance to observe and take some notes on how people gained access to the stadium. The paper tickets were collected in the normal fashion by tearing off a part of the ticket, but the use of the electronic tickets was more complicated. The results from the observation together with questions from the survey were used to form an interview guide.

2.5.3 Interviews

The survey was already up and running and observation performed before the semi-structured interviews were conducted. After observing for nearly an hour at the game of Sandefjord I made the interview guide and then started to ask people entering the arena if they wanted to speak with me after introducing the topic of my research. Since I had no tape recorder, I wrote down the answers after the interview

before conducting another one. The interview guide was also used in Kristiansand when I attended the game there and I used the same approach as I did in Sandefjord to come in contact with people.

2.6 Summary

Different research methods were reviewed and described in this chapter. A mixed method approach was chosen and this is a model which combines both qualitative and quantitative research methods. The point of this model is to try to balance the weaknesses and the strengths of the different methods. Applied methods are questionnaire, observation and interview.

3 Theoretical approach

This chapter will be divided in two main parts. The first part will try to place this thesis in a framework where Ubiquitous computing is central and main concepts will be developed and used later on in the discussion with the findings from my empirical investigation. There exists several definitions of the word ubiquitous, but they are mostly similar. The Oxford dictionary says that: "Ubiquity is the ability to be present everywhere or at several places at once. The term is derived from Latin ubique which means everywhere" (Hornby et al., 2000). What follows from this definition is that RFID is a ubiquitous technology as it is present everywhere and around us.

The second part will look further into the notions of user, technology, user acceptance and the innovation of diffusion theory. The focus of this thesis is on a new ticket system based on RFID which is used on football arenas around Europe and how users perceive and experience this technology and why they choose paper or electronic tickets.

3.1 Framework

3.1.1 From the desktop metaphor to Ubiquitous computing and the invisible computer

In Oxford Advanced Learner's Dictionary (Hornby et al., 2000) desktop is described as "The top of a desk" while metaphor is described as "A word or phrase used in an imaginative way to describe sb/sth else, in order to show that the two things have the same qualities and to make the description more powerful […]"

In the light of descriptions given, the desktop metaphor means that the office desktop has been brought to the computer and are being simulated there. On your desktop you might have a notepad, clock, calculator and other accessories. The point of representing your usual desktop items in a user interface is to make the system more familiar for users and thereby easier to use. Other features such as the paper can and file cabinets have extended the desktop metaphors even though these items are not normally found on a desktop.

The desktop metaphor was first brought to life and the first generation of Graphical User Interface (GUI) was established when Xerox in 1981 announced the 8010 Star Information System. It was a workstation designed for offices and the first system using windows, icons, menus and pointers (WIMP). The WIMP paradigm was originally used on the Xerox Alto experimental computer, but became commercial with Star. Xerox used over 30 work-years to design the Star user interface and it was designed before any line of code was written at all. Before they started the work of designing the interface they developed a methodology with several important Human-Computer Interaction (HCI) principles. Among them is the famous principle of "what you see is what you get" which is broadly used in the computing world today. Other principles include "seeing and pointing versus remembering and typing" and "modeless interaction" (Smith et al., 1982). These principles were taken further by Apple who had ten fundamental design principles for the Apple Desktop Interface (Apple, 1987). One of the important design goals of the Xerox Star system

was to make the computer as invisible to the user as possible (Johnson et al., 1989). This is in correlation with Mark Weiser's vision of the computer for the 21st century which will be reviewed later.

Apple Computer and Steve Jobs started the development of Lisa in 1979 and the work was led by Jef Raskin. A screenshot of Lisa can be seen in figure 3-1. Lisa was completed and introduced in 1983 and it was a system which was easy to learn, it allowed for interruptions and it was fun to use. The work with Lisa was influenced by research and work done at Xerox PARC, especially the Smalltalk system (Ingalls, 1978) and the already mentioned Star. Lisa functioned as a bridge between the Xerox Star and the Macintosh which was released in 1984, in the way that the concept of GUI was extended (Perkins et al., 1997). Macintosh was the first commercial product which succeeded in using a GUI and the team developing Lisa and Macintosh consisted of several previous members from Xerox and there is still discussion about where the Macintosh user interface came from. The fact remains that Steve Jobs visited Xerox PARC and watched a demonstration of Smalltalk. This visit gave ideas to the Macintosh team which together with their own ideas developed the system. Bruce Horn was one the persons who left Xerox for Apple where he became one of the main designers of the Macintosh and he wrote an article about the differences between the Smalltalk and the Macintosh and it clearly states the many differences between the systems. One was that Smalltalk had a three-button mouse and popup-menus while the Mac had one-button mouse and a menu-bar (Horn, 1996). There have been many systems using GUI in the years after the Macintosh and GEM, Amiga Workbench and GEOS are only some examples. The best known systems today are Microsoft Windows and Mac OS X (Reimer, 2005).

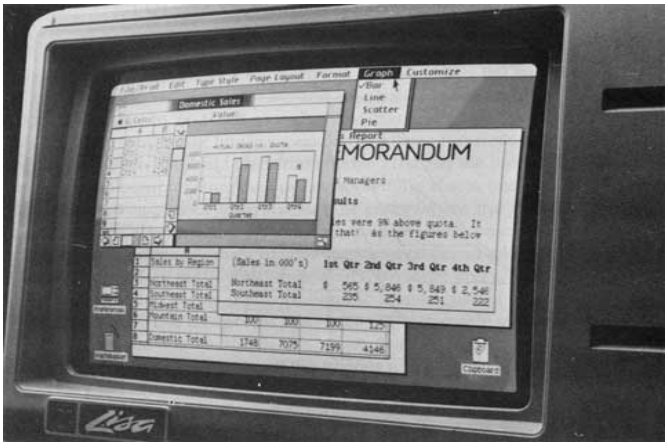

Figure 3-1: Apple Lisa, 1983. Menu bar on top of the screen (Müller-Prove, 2002)

The desktop metaphor is well established and used and extended in many ways, but what is the metaphor for the computer of the future? This question is asked by Mark Weiser in his article "The World Is Not A Desktop" (Weiser, 1994a). He explains why neither multimedia, intelligent agents, virtual reality nor voice input is the metaphor for the future because all these concepts have the same basic flaw which is making the computer visible. Weiser's vision of the computer for the 21st century was for the

computer to be invisible. In "Creating the Invisible Interface" he writes about two paths most computer and interface design have been following the last 30 years; one "dramatic" and another less used path "invisible" where "its highest ideal is to make a computer so imbedded, so fitting, so natural, that we use it without even thinking about it." Weiser called this notion Ubiquitous computing (Weiser, 1994b).

Ubiquitous computing is a computing paradigm and the third through the history. The two previous ones have been the main frame computing where many people shared one computer and the desktop computing where one person shared one computer. Ubiquitous computing however is meant to be one person sharing many computers. Mark Weiser was working at Xerox Parc when he proposed the paradigm of Ubiquitous computing in his article "The Computer for the 21st Century (Weiser, 1999).

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

- Mark Weiser (Weiser, 1999)

Weiser originally got the idea of Ubiquitous computing after understanding which position the computer has in activities in our everyday lives after reading articles from anthropological studies. He understood that the ordinary man and woman does not have a lot of technological knowledge and therefore finds using the computer stressful (Weiser, 1993). The computer is a tool and a good tool is an invisible tool in Weiser's opinion, but the computer often remains in the centre of attention (Weiser, 1994a). Examples of good tools are for example eyeglasses or a cane. When you use eyeglasses, you just look at everything around you, but keep forgetting that you are actually using a tool. The goal and aim of Ubiquitous computing was to enhance the use of computers by deploying many computers in the physical environment, but the computer should be invisible to the user instead of in focus of attention. These thoughts were shared by colleagues and fellow-researches at Xerox PARC where they started a Ubiquitous computing program in the Computer Science Laboratory (CSL) in 1988. They wanted to solve some of the existing problems with personal computer like for example that the computer is too hard to use. The project ended up with many published scientific papers, unanswered questions and a huge problem. The problem was one of control and privacy. As computers are everywhere and invisible to users, questions like where information is going and who controls who rises. These questions and others were often discussed in newspapers and maintaining control is one of the largest open questions in Ubiquitous computing research today. Ubiquitous computing became in the end a new field of research in computer science (Weiser et al., 1999).

Even though Mark Weiser passed away in an early age, his vision of the invisible computer has led the way for other related perspectives such as Unremarkable Computing, Context-Aware computing and Calm Computing which was proposed by Weiser himself. These theories will be discussed in the following sections.

3.1.2 Unremarkable computing

Mark Weiser's vision was to make the computer and technology invisible in use. This is known to be one of the most difficult design issues in Ubiquitous computing. Unremarkable computing wants to address this issue and contribute to the research area of Ubiquitous computing. Instead of focusing on the office environment like Weiser did, the authors of the article "Unremarkable computing" (Tolmie et al., 2002) studied the home environment. The point of the ethnographic study was to investigate people's everyday activities and routines and take a closer look at what routines people treat as unremarkable.

The researchers of the article lived one out of the time in five different homes in the period of a year. This was done not just to be a passive observer, but to get to be an accepted member of the home and thereby obtaining access to the other members' thoughts and understanding. All people have routines in our daily life like for example waking up at seven o'clock every day to go to work or washing our hands before eating dinner. Routines make life easier in the way that we do not have to wake up every morning and think through every action of the day. The instances of a knock on the door, the alarm clock and going to the coffee shop are reviewed in the paper. The example with the alarm clock showed that the person involved did not even react when the alarm went off. It was a routine hearing the alarm go off every morning and by not reacting on the event, the alarm was treated as unremarkable.

Tolmie *et al* (Tolmie et al., 2002) studied routines to find out what was invisible about them and one of the results from their study was the discovery of routine invisibility or also called unremarkable routine. Their research showed that routines are invisible for the persons involved in them, but also that nobody talks explicitly about their routines because that would make them significant and mark them out instead of being unremarkable. Designing invisibility is not easy and there is a clear difference between visual and perceptual invisibility. While for example the alarm clock can be made small and almost visually invisible, the goal for Weiser was invisibility in use. Later Weiser and his colleague John Seely Brown came up with the idea of an approach called Calm computing. This was an approach for fitting technology in our lives (Weiser and Brown, 1997) and was developed by Weiser and Brown.

3.1.3 Calm computing

"The important waves of technological change are those that fundamentally alter the place of technology in our lives. What matters is not the technology itself, but its relationship to us". This quotation is the opening phrase of the article "The Coming Age of Calm Technology" by Weiser and Brown (Weiser and Brown, 1997) who predicts the era of Ubiquitous computing.

The last fifty years of computation have been dominated by two major trends which are the mainframe and the personal computer. In mainframe computing many people shared one computer and with the personal computer came the trend where everybody owned their own computer which they could customize after their own needs. Weiser and Brown predicts in the article the next trend to be Ubiquitous computing which will take over for the personal computer in the year 2005 and last at least fifteen years. In Ubiquitous computing there will be computers in chairs, sofas, walls and cars. In other words, computers will be everywhere.

Throughout history there have been two technologies which have become ubiquitous and these are writing and electricity. These are so common and usual for everyone that people have completely forgotten how much they mean to us and that they even exist. Weiser and Brown are of the opinion that people will experience the same with Ubiquitous computing

According to Weiser and Brown (Weiser and Brown, 1997) the largest change implied by Ubiquitous computing is the focus on calm. If computers are to be everywhere, they should not come in the way of people's everyday life and activities. The authors predict calmness to become an important challenge for the technology in the next fifty years.

The article introduces the concepts of centre and periphery of attention and these are both engaged by calm technology and moves back and forth between the two. Periphery can be described as something you are attuned to without paying explicit attention. One moment something can be in the periphery while in the next it is in the focus of our attention. An example is driving a car. When you are driving you are concentrated on the road and not to the sound of the engine, but if the engine suddenly makes an unexpected sound, it quickly comes into our centre of attention. Weiser and Brown argue that technology must be designed for the periphery. In that way, people can take control of the technology instead of being dominated by it.

3.1.4 Tangible computing

Tangible User Interfaces (TUI) is a new type of HCI which Ullmer and Ishii are trying to establish to make computing ubiquitous and invisible (Hiroshi and Brygg, 1997). Their work was, among others, inspired by Mark Weiser's vision of Ubiquitous Computing (Weiser, 1999).

In the article "Tangible bits" TUI is presented as an alternative to the traditional GUI (Brygg and Hiroshi, 1997). Tangible computing allows the users to interact directly with computational artefacts by manipulating everyday physical objects instead of using traditional graphical interfaces and physical devices like mouse and keyboard (Ullmer and Ishii, 2000). Digital information is given physical form by tangible interfaces. TUI couples physical relations with digital representation which creates user interfaces which are computationally mediated, but are not generally regarded

as computers (Brygg and Hiroshi, 1997). One of the great advantages with tangible interfaces is that they support multi-user interaction (Scott et al., 1998). There are many examples of systems which have been developed in order to illustrate and show the principle of tangible interfaces (Piper et al., 2002), (Steven et al., 2001), (Brygg and Hiroshi, 1997).

The goal of tangible bits is to close the gaps between both the physical environment and the virtual environment, but also the background and foreground of human activities. This goal is going to be achieved by making digital information (bits) tangible (Hiroshi and Brygg, 1997). Tangible means capable of being touched or something that have an actual physical existence (Dictionary.com, 2006). In "Tangible bits" the authors are trying to develop different ways of making bits available in the physical environment by using three key concepts which are interactive surfaces, coupling of bits and atoms and ambient media. By enabling users to be aware of background bits at the periphery using ambient media in an augmented space and by allowing users to grasp and manipulate foreground bits by coupling bits with physical objects, the authors want to accomplish to improve the quality and obtain more interaction between digital information and people (Hiroshi and Brygg, 1997). The concepts of centre and periphery of attention were also mentioned in calm computing (Weiser and Brown, 1997), but foreground and background are two new notions which Ullmer and Ishii were stimulated by after reading an article by W. Buxton (Buxton, 1995).

3.1.5 Ambient intelligence

Ambient Intelligence (AmI) is a new paradigm consisting of many different disciplines like intelligent systems research, context awareness and social interaction (Shadbolt, 2003). The paradigm has been inspired by the ideas of Norman (Nijholt et al., 2004) and by the ideas of Ubiquitous computing and Mark Weiser. AmI provides the basic criterias for developing intelligent environments, but also supports the design of next generation of intelligent systems along with introducing new ways of communication between machine, man and the surrounding environment (Remagnino and Foresti, 2005).

In the near futures it is possible that AmI systems will help the user by interpreting his/her intentions and in addition understand and adopt the routines of the user in the environment. Today systems exist where the system detects that a user is present in the room and adjusts the light and the temperature. This is done by computers which are everywhere in the room; in chairs, walls and tables, but which remain invisible for the user. Michael Coen from MIT Labs has made this comment about the effects smart environment has on its users: "The notion of being alone may disappear, or it may be changed drastically." And, "You may be in a room that's always alive and aware. And from my experiences here… when the space is 'off', you feel it. You notice that it's not reacting. There's a void." (Nijholt et al., 2004) AmI can watch after the user and thereby create a kind of safety-net for the user and this correlates which Coen's comment about the notion of never feeling alone. In the

same article as Coen's comment, which is "Lost in Ambient Intelligence", the authors ask the question of who the users are going to talk to in the intelligent environment? It is after an all an anonymous environment which surrounds the users at all times. They also ask the question if it is possible to create some kind of relation to the environment in the same way as humans have with each other.

One of the principles for the design of a smart environment is that the system must have a pervasive and invisible infrastructure which is able to learn to know the user without prying too much into the user's life or be in the centre of attention. The system can be implemented and customized after the users needs and help users with daily chores both at home and in the office (Remagnino and Foresti, 2005).

AmI is user-centric and wants the user to be in the foreground. The human user is supposed to be the main actor and always be in control and play several parts in the society, but by having the human user in the foreground, legal and ethical implications occur. When it comes to technology in AmI, it is deployed to make computers disappear in the background and move into the periphery of attention (Remagnino and Foresti, 2005). These thoughts and concepts have been used previously in others type of computing like for example calm (chapter 3.1.3) and the influence from Weiser and his vision of Ubiquitous computing is clear and easily recognized.

3.1.6 Summary

Ubiquitous computing is a computing paradigm and the third through the history and was introduced by Mark Weiser. The goal of Ubiquitous computing was to enhance the use of computers by deploying many computers in the physical environment, but the computer should be invisible to the user instead of in focus of attention. Weiser's vision of the invisible computer gave influence to other related perspectives like Unremarkable Computing, Context-Aware computing and Calm Computing which introduced notions of visibility/invisibility, unremarkable routine, centre and periphery of attention which all will be discussed in relation with the findings from the empirical investigation.

3.2 User acceptance

User acceptance of technology is often described in IS literature as one of the most mature areas of research (Venkatesh et al., 2003). During the years there have been developed many different theories and models to try to explain and predict the use of technology. Theory of reasoned action by Fishbein and Azjen (Fishbein and Ajzen, 1975) , theory of planned behaviour by Ajzen (Ajzen, 1991), the unified theory of acceptance and use of technology (UTAUT) by Venkatesh et al. (Venkatesh et al., 2003) and innovation of diffusion theory by Rogers (Rogers, 2003) are only some examples.

What a user is, what technology is, what user acceptance is and a more thorough review of IDT will follow in this chapter.

3.2.1 What is user acceptance?

User acceptance is defined as "the demonstrable willingness within a user group to employ information technology for the tasks it is supposed to support" (Dillon, 2001). According to this definition users have a degree of choice to either accept or reject the technology. According to Rogers (Rogers, 2003) there are three types of innovation-decisions. Optional innovation-decision is where the individual is free to adopt or reject an innovation. Collective innovation-decision is where the choice to adopt or reject an innovation is made together with other individuals. Authority innovation-decision is where the choice to adopt or reject an innovation is made by a few number of individuals and most probably the leaders of an organization or someone with status or technical expertise. The president of a firm can for example decide that all the employees must wear a certain type of outfit. The definition of user acceptance belongs to the category of optional innovation-decision.

The lack of user acceptance is a large hindrance to the success of new information systems. If new systems will result in higher performance, there are research showing that users can be unwilling to use them. This is a deliberate act in order to prevent higher pressure on the work of the users. Due to this user acceptance has been viewed as the most important factor in deciding success or failure of a system project (Dillon and Morris, 1996).

During recent decades a lot of money has been invested in information technology, but the question remains if these investments have led to the intended goals and if the intended users are actually using the new information technology. Researchers are interested in finding out and understanding which factors which influence the adoption of information technologies in order to be able to minimize the rejecting from the users (Dillon, 2001).

It exists a lot of literature on user acceptance and every piece contribute to get a deeper and more complete understanding of the subject, but the issue is complex and it is not very likely that a single theory or model will explain all aspects of user acceptance of technology and information systems.

Before introducing the notion of innovation diffusion theory, it might be useful to define and look further into the notions of a user and technology.

3.2.2 What is a user?

A user is a human who interacts with technology and it can for example be a washing machine, a stereo or a personal computer. All persons living in the world

today are users in one aspect or another. In the area of HCI which this thesis lays within, the focus is on the relationship between technology in the form of the computer and the human user. Users have their needs and one of the goals of HCI is to make computers more user-friendly and more receptive to the needs of the users.

3.2.3 What is technology?

There are many different definitions of technology. Oxford dictionary (Hornby et al., 2000) explains technology as "the scientific study and use of applied sciences" while Rogers (Rogers, 2003) defined technology as "a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome". Technology is usually consisting of two parts further according to Rogers (Rogers, 2003); one component being the software and the other the hardware. Computer hardware consists of transistors, electrical connections and semiconductors. Computer software is programs or tools with manuals to accomplish certain tasks on the computer hardware. Without the hardware the software has no use and of course the other way around. The two components have a close relationship.

Many new products today consist of both a hardware and a software component. The hardware is sold first in order for the software to be utilized and sold later. Typical examples are dvd-players and dvd's, compact disc players and cds and the personal computer and software programs. When the companies sell their hardware, they know that consumers must buy software to fully take advantage of the hardware. They sell the hardware at a relatively low price to capture a certain market share and the software at relatively higher price. Typical examples here are video games like Playstation, Nintendo and Microsoft. These companies compete against each other and want a largest piece of market share as possible. By introducing their machine at a low price, they later on sell their games at a high price. This can be done because of the close relationship between the machine and the games.

3.2.4 Innovation of diffusion theory

According to Dillon & Morris (Dillon and Morris, 1996) IDT might be the principal theoretical perspective on technology acceptance. In his book "Diffusion of innovation" (Rogers, 2003) Everett Rogers defines diffusion as "the process in which an innovation is communicated through certain channels over time among the members of a social system". In the definition are four key elements which are present in the diffusion of innovation process. These are innovation, communication channel, time and social system where innovation is most important. Innovation is defined by Rogers as "an idea, practice or object perceived as new by an individual or other unit of adoption".

To go back to the beginning of the diffusion theory, we have to look in Europe nearly one hundred years ago. New social sciences as sociology and anthropology were

making its way and it was the French sociologist Gabriel Tarde who made the first diffusion research in 1903. He used other concepts than Rogers use in his book like for example imitation instead of adoption, but Tarde was far ahead of others in his thoughts about diffusion. He discovered that the rate of adoption of a new idea usually followed a curve shaped as the letter S. Tarde also proposed several laws and one of them was the law of imitation which claimed that the more similar an innovation is to ideas that have already been accepted, the more likely the innovation will be adopted. Rogers describes in his book this law as the perceived compatibility of an innovation (Rogers, 2003).

In 1940 the two sociologists Bryce Ryan and Neal Gross renewed interest in the diffusion of innovation research by studying hybrid-corn adoption among Iowa farmers. The result of the study was that the adoption of the innovation followed an S-shaped curve which can be seen in figure 3-2 and this was similar to the one Tarde presented in the beginning of the 20th century (Hornor, 1998).

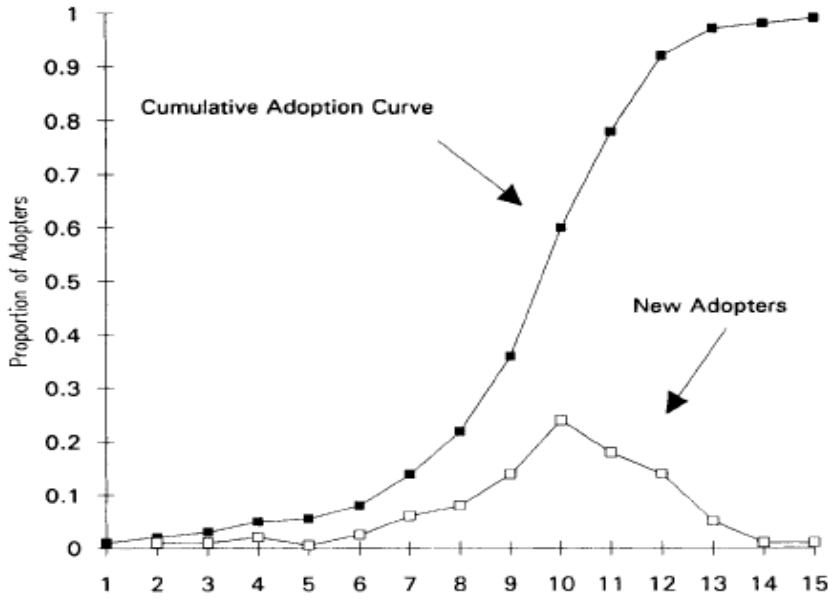

Figure 3-2: The results from the study by Ryan and Gross of farmers in Iowa (Valente, 1993)

Ryan and Gross later on put the farmers into different categories after how much time the different farmers used before adopting the innovation of hybrid corn seed. The categories and the relative sizes of these groups and the sequence of adoption can be seen in figure 3-3.

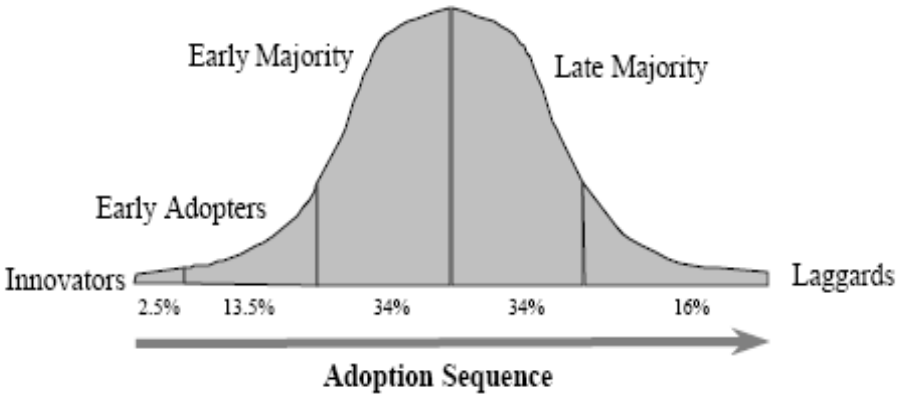

Figure 3-3: Categories of adopters and adoption sequence (Mcconnell, 2004)

There are certain individual characteristics which place users into the different categories. Rogers (Rogers, 2003) identified these to be:

- Innovators are venturesome, have a high ability of technical knowledge, need to be able to handle uncertainties about innovations and are risky.

- Early adopters are respected by their peers, integrated part of the local social system, high degree of opinion leadership and kind of put their stamp of approval on a new innovation by adopting it.

- Early majority are deliberate before adopting a new idea, adopt just before the average member of a social system and seldom hold the position of opinion leadership.

- Late majority are sceptical, cautious, do not adopt before other individuals have done so and adopt just after the average member of a social system.

- Laggards have no opinion leadership, use the past as a reference, are suspicious of innovations and have limited resources in the way that they can not afford the adoption to fail.

In addition to personal characteristics there are also other variables which influence which type of category the adopter belongs to. Exposure to mass media, cosmopolite/localite, interpersonal communication, opinion leadership, change agent contact and advice seeking are all decisive in categorizing the user (Rogers, 2003).

There have been several different names and types of categories developed and used in research studies, but Rogers' adopter categories are the most preferred in research today. These categories all show factors and characteristics of accepting users, but there are also characteristics of acceptable technology. According to Rogers (Rogers, 2003) there are five attributes which determine the acceptance of technology:

- Relative advantage - the degree of which new technology offers improvements over currently existing tools

- Compatibility – consistency with past experiences, existing values and the needs of potential adopters

- Complexity – the ease of use and understanding

- Trialability – the possibility to try out the innovation before adopting it

- Observability - the extent to which the results of an innovation is visible to others

There are many studies confirming that technology with these characteristics will more easily be accepted and adopted than innovations without these. Some characteristics are more important and have more influence than others and this especially goes for relative advantage, compatibility and lack of complexity since complexity is otherwise negatively regarded. Even though Rogers' model is widely used, there are however concerns that the characteristics are too loosely defined (Dillon, 2001).

3.2.5 Summary

The research on user acceptance has led to several theories and models and one of these is IDT by Rogers (Rogers, 2003). He developed a model of adopter categories and this model is the most preferred in research today. According to different factors and characteristics of users, they are put into the different adopter categories which are innovators, early adopters, early majority, late majority and laggards. A categorization of the respondents from the questionnaire will be made later on in this thesis.

4 Technical Focus – RFID

This chapter is about the RFID technology, how it works, the history and an overview of application areas.

4.1 RFID

4.1.1 What is RFID?

Radio Frequency Identification is a term which has evolved during time to stand for a family of technologies. Generally it is used to describe any technology that uses radio signals to identify specific objects. In other words this means any technology that transmits specific identifying numbers using radio. These technologies allow cheap chips to communicate data wirelessly to an interrogating reader which is located at some distance (Juels et al., 2005). It is a technology for automated identification of objects and people. While humans find it easy to identify objects, computers perform the same kind of tasks rather poorly (Juels, 2006).

Many stores today use a system called Electronic Article Surveillance (EAS) to trigger an alarm when an item is stolen, but this is not RFID since the EAS tags do not have unique serial numbers like the RFID tags do. However both RFID and EAS go under the term AIDC which stands for automatic identification and data collection. Other examples of known AIDC technologies are bar codes, optical character recognition and magnetic ink character recognition (Rosenberg and Garfinkel, 2005).

An RFID device, nowadays just called an RFID tag, is an electronic device which holds data (Molnar and Wagner, 2004). It is a small microchip designed for wireless data transmission (Juels, 2006). These tags are typically attached to an item and contain a serial number or other data connected with that item (Molnar and Wagner, 2004). In response to interrogation from an RFID reader, the RFID tag transmits data over the air (Takaragi et al., 2001).

For over the last twenty years consumer products have been identified by optical barcodes and one of the most familiar optical barcode is the Universal Product Code (UPC). UPC was invented in 1973 and is today found on many different products bought by consumers (Weis, 2005).

The type of RFID barcode device which is going to replace UPC is called electronic product code (EPC) (Juels, 2006). EPC is RFID tags which are incredibly cheap to produce and they are designed to be used in supply chain management, retail checkout and inventory management (Weis, 2005). The EPC tags have several advantages over optical barcode systems. Tag data may be read automatically, without line of sight, through non-conducting materials such as paper or cardboard, at a rate of several hundred tags per second and from a range of several meters (Weis, 2005).

There has been a need for bringing together researchers, manufacturers and users to develop standards for supply chain management and the AutoID center at Massachusetts Institute of Technology was established to perform this goal (Landt, 2005). EPC Global Inc is the name of the organization which has the main responsibility for overseeing the developments of standards for the RFID tag (Juels, 2006).

The concept of RFID is far from new, but the term has only been used for the last couple of decades (Landt, 2001). More about the origin of the technology can be read in the next chapter.

4.1.2 The history of RFID

The basis for this kind of technology has existed for a long time and most histories trace the technology all the way back to World War II. A radio-based identification system was used by the Allied bombers when they fought against Germany. The night was the best time to fly bombing missions since it became harder for the Germans to see the planes. The Germans also attacked during the night and a system was needed to distinguish enemy planes from their own when the bombers returned. Early Identification Friend or Foe systems made this possible and the idea was to send coded identification signals by radio. If an airplane replied with the wrong signal, it was a foe. Otherwise it was a friend. This was the birth of radio frequency identification (Rosenberg and Garfinkel, 2005).

RFID was invented in 1948 when Harry Stockman released the paper "Communication by Means of Reflected Power" (Stockman, 1948). He was an engineer who realized that it is possible to use the strength from a received radio signal to power a mobile transmitter. This was the presentation of the first passive RFID system and it was at the time the first work exploring the RFID technology. In the following decades and until today there have been a lot of work and research concerning RFID. The 1950's were influenced by early explorations of RFID technology and laboratory experiments were conducted. Through the 60's and 70's there were an explosion of RFID development, several tests were conducted and the theory of RFID was developed (Landt, 2005). For example at the Lawrence Livermore Laboratory some researchers discovered that a handheld receiver stimulated by RF power could send back a coded radio signal. By connecting this system to a computer, the system could be used to access control to buildings and secure facilities (Rosenberg and Garfinkel, 2005).

During the 80's commercial applications of RFID entered the mainstream and from that time on RFID has been widely deployed with several standards and it has even become a part of our everyday lives (Landt, 2005). The technology has increased our convenience and it used for maybe as many as thousands of different applications and some of these will be examined later in this chapter.

4.1.3 Elements of an RFID system

An RFID system as shown in figure 4-1 consists of four elements:

- RFID tag
- RFID reader
- Antenna and choice of radio characteristics
- Computer network

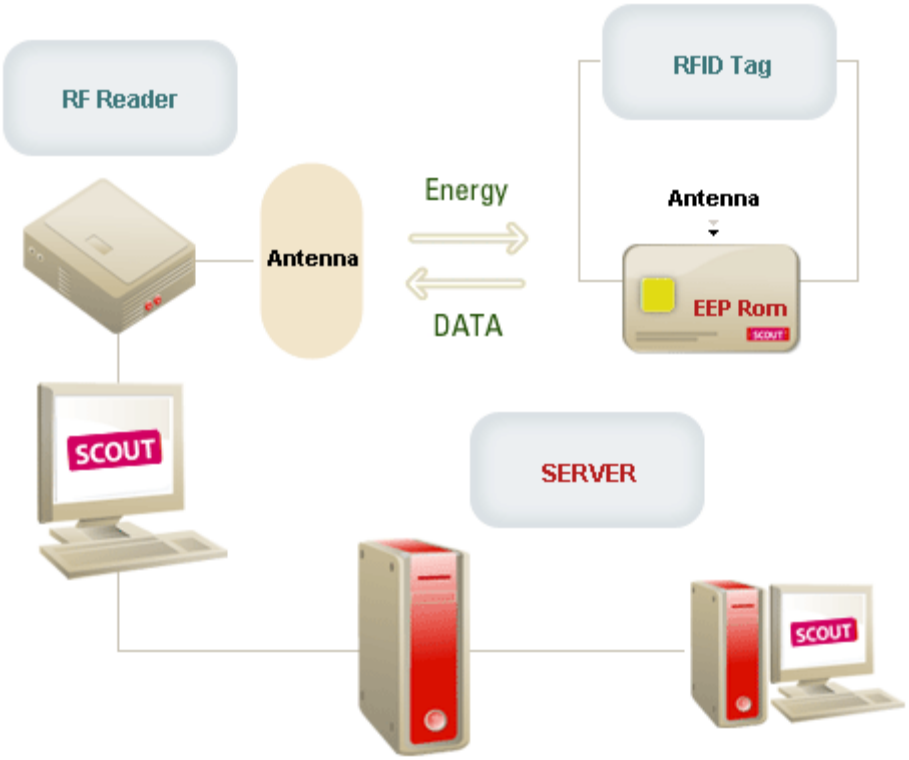

Figure 4-1: Overview of an RFID system (Sfscout.com, 2006)

4.1.3.1 The RFID tag

The tag is the main part of an RFID system. It is built up by an antenna and a silicon chip which contains some memory, control logic, radio receiver, a power system and a radio modulator. The tags can either be powered actively or passively. The difference is that active tags contain a on-board power source which normally is a battery while the passive tags is powered by the interrogating RF signal from the readers. This means that the passive tags can be much smaller and cheaper because they do not have batteries and therefore also live longer. The power of the tag decides at what range the tag can be read. This means that active tags can be read at greater distance than the passive tags because of the power source. The passive tags on the other hand are usually inactive and can only perform calculations in the area

where a reader is present. Active tags can perform calculations and may also record sensor readings in the absence of a reader (Weis, 2005).

In addition to active and passive tags there are semi-passive tags. These are like the passive tags in the way that they use the reader's power to transmit a message back to the RFID reader and like the active tags in the way that they have a battery. This way the semi-passive tags have the read range of a passive tag and the read reliability of an active tag (Rosenberg and Garfinkel, 2005).

RFID tags come in all shapes and sizes. The Hitachi mu-chip is the smallest chip known to be produced and it is no more than 0.4mm on a side. It is used for tracking documents and it is embedded in the paper. The mu-chip is a passive tag because otherwise it would need a larger antenna (Rosenberg and Garfinkel, 2005).

When several tags are nearby a reader, they can interfere with each other and make it difficult for the reader to distinguish which signal comes from which tag. For some systems this is not a problem since only one tag is within the range of the reader at once. Meanwhile for other systems it is of great importance to read multiple tags at once. The solution to this problem is that the application supports either a singulation or an anti-collision protocol. The singulation protocol allows the reader to acknowledge that there are several tags present and allows it to iterate the tags one of out the time (Rosenberg and Garfinkel, 2005).

4.1.3.2 The RFID reader

The functionality of an RFID reader is fairly simple. It sends a pulse of energy to the tag and waits for a response. As mentioned previously, this pulse of energy powers the passive tags. The tag detects the energy and sends back an answer which usually is the unique serial number of the tag. With passive tags the pulse is just an on/off switch while in more advanced systems the pulse can contain commands, instructions and passwords. In the beginning an RFID reader could only communicate with a certain type of tag, but nowadays multimode reader has become more and more common (Rosenberg and Garfinkel, 2005).

Some RFID readers are constantly sending radio energy and waiting for a tag nearby to answer while other readers have triggers and are only sending energy when the triggers goes off. In certain kinds of systems like the electronic toll collection it is absolutely necessary for the reader to constantly send out energy to record every vehicle that passes (Rosenberg and Garfinkel, 2005).

4.1.3.3 Antennas and choice of radio characteristics

The way radio energy is measured is through frequencies at which the energy oscilliates and the strength of these oscilliations. The FM broadcast stations in the United States for example, transmit with energy at frequencies between 88MHz and

108MHz or in other words, 1 million oscilliations per second (Rosenberg and Garfinkel, 2005).

There are generally three frequency ranges of usage in RFID systems: LF, HF and UHF. Table 4-1 summarizes these ranges. 125kHz, 13.56MHz and 2.45GHz were early pointed out as representatives for the different ranges.

Frequency Band	Characteristics	Typical Applications
Low 100-500 kHz	Short to medium read range Inexpensive Low reading speed	Access control Animal identification Inventory control Car immobilizer
Intermediate 10-15 MHz	Short to medium read range Potentially inexpensive Medium reading speed	Access control Smart Cards
High 850 – 950 MHz 2.4 – 5.8 GHz	Long read range High reading speed Line of sight required Expensive	Railroad car monitoring Toll collection systems

Table 4-1: Frequency ranges of usage in RFID systems (Dowla 2004)

With a larger antenna on both the reader and the tag, the RFID system will work much better because this means better transmitting and receiving in both ends. With a larger antenna on the tag, it can collect even more power from the pulse sent from the reader. With a larger antenna on the reader, more power can be sent to the tag (Rosenberg and Garfinkel, 2005).

4.1.3.4 Computer network

Several readers can be connected to a computer network. Take for example a system with access control. All the doors in a building can be equipped with an RFID reader. The smart card with an embedded RFID tag sends its unique serial number to the reader which passes it on to the connected computer to check if the number is allowed to enter the specific door. If the number exists, the door will unlock. In an electronic toll collection system the RFID tag in the bypassing car will be interrogated by an RFID reader. The tag responds with its serial number. If the serial number is found in the computer connected to the reader, a green light will show and the car can pass (Rosenberg and Garfinkel, 2005).

4.1.4 Security and privacy issues

RFID is a technology which has become a part of our everyday lives. It is everywhere around us and naturally people are starting to ask questions about the privacy concerns regarding RFID. In fact, the issue of personal privacy is perhaps the most

prevalent issue related to the use of RFID. Tags are being used in clothing, manufacturing, retail and document tracking to mention some. With so many application areas and so many RFID readers present, there for example exists the possibility of tracking every move of an individual. Toll-payment transponders like used in Autopass in Norway are common around the world. In a court case the data gathered from a transponder were use to undermine the alibi of the defendant in the case. By collecting information from the transponder it can be possible to know where and when a car has passed a toll collection station and thereby knowing every move of people enrolled in the program. When it comes to libraries, RFID systems are implemented to help facilitate check-out of books and other tasks. The privacy concern in this matter is regarding the monitoring of book selections which makes it possible to establish profiles of the users of the libraries (Juels, 2006). Much of the concerns with privacy are due the minimalist design of the EPC tags.

EPC tags today cost less that 13 U.S. cents per piece if they are bought in large quantities. If an explosion in the use of RFID tags is to occur, the price should be as low as 5-10 U.S. cents ((Juels, 2006), (Takaragi et al., 2001)). RFID readers however cost several thousand of dollars and the price is expected to stay high. For the price to stay low for RFID tags, the design has to be minimalistic and this makes it impossible to implement security measures like hash function or symmetric encryption schemes. What to be expected of security is limited to simple comparisons of passwords with the present design of the tags (Molnar and Wagner, 2004).

In his article about RFID security and privacy, Ari Juels (Juels, 2006) states that for users there exist two main privacy concerns and these are clandestine tracking and inventorying. When an RFID tag is nearby an RFID reader and within read range, the reader can interrogate the tag without the knowledge of the owner. The tag has an unique ID which can be picked up by any reader and therefore makes clandestine tracking a possible threat, but it does not stop there. If the fixed serial numbers are combined with personal information of a user it may be possible to establish profiles of customers and the shops may take advantage of this to their own gain. Other wireless devices such as Bluetooth may also be affected by the opportunity of clandestine tracking. Juels (Juels, 2006) states that because of the minimalistic infrastructure of RFID today, clandestine tracking and inventorying does not represent a huge problem, but when the deployment of RFID explodes as it is expected to, the privacy concern will be enormous .

There are several solutions for the protection of consumer privacy proposed by researchers in literature. There is the “Blocker Tag” (Juels et al., 2003), one approach is based on energy analysis (Fishin et al., 2004), the Hopper and Blum protocol (Weis, 2005) , Hash-Bases Access Control (Weis, 2005) and many others. Juels (Juels, 2006) finds it astonishing to see how a little device such as the RFID tag can create such a large area with regards to privacy and security.

4.1.5 An overview of applications

There are today so many applications of RFID which makes it almost impossible to categorize them all, but Garfinkel and Rosenberg (Rosenberg and Garfinkel, 2005) have made an effort. They suggest these different categories of present use and they are supplied with applications from other literature:

- Manufacturing
- Distribution and Inventory
- Retail
- Document Tracking
- Security
- Food Supplies
- Healthcare

Manufacturing
Manufacturing is a difficult task. It is the process of transforming raw materials into finished goods by using certain tools. The goods are later sold. Vision systems, barcodes and RFID have all been used in manufacturing to identify items or making sure the products are of good quality (Rosenberg and Garfinkel, 2005). Recently there are more and more manufacturers which are turning to RFID and Ford is one of them. At Ford Motor Company's Essex engine plant in Windsor, Canada, they previously used barcodes to track engines during the production, but the problem was that data could not be written to labels because they were easily damaged or broken. RFID is more flexible, functions well under difficult conditions and is now Ford's preferred choice. In addition can the RFID tag hold much more data and therefore makes it possible to extend the system even further (AIM, 2004).

Boeing and Airbus are two of the largest manufactures of aircrafts in the world and they are both using RFID in the tracking of parts through their supply chain. The two companies are both supporting the Global Aviation RFID Forum which is working towards a standard for using RFID on commercial airplanes (AIM, 2004).

Distribution and Inventory
Keeping a tight control over the inventory makes the suppliers sure they can deliver an order quickly and correctly and this keeps costs down to a minimum. During the "Operation Desert Storm" in 1991 the DoD experienced the need for keeping an accurate inventory in order to be able to quickly locate and identify cargo containers containing equipment and other material. After that war the DoD wanted all its 30000 suppliers to issue all shipments with RFID tags and during the recent "Operation Iraqi Freedom" the investment gave efficiency results (Rosenberg and Garfinkel, 2005).

Volkswagen is one of the largest producers of cars in the world and has a Auto City at Wolfsberg in Germany where over 35.000 cars are collected every year. After each car is complete, the vehicle is placed in the parking lot. Before the car is ready for

delivery, it has to be washed, vacuumed, cleaned and undergo a security check. In order to locate the car more easily in the parking lot, Volkswagen decided to use a system based on RFID which makes it easy to keep control over the car during the whole process before delivery (AIM, 2004).

Retail
Maintaining stock levels of merchandise such as food or fashion has been easier with the use of RFID. The system can record sales, check inventories and if the inventory is low, order the goods needed. The benefit is that the amount of wasted goods is reduced, but also that the shoppers are ensured that the goods in the shelves are fresh. RFID tags have also been useful in reducing theft from the stores or in the supply chain (Rosenberg and Garfinkel, 2005). Sainsbury's Supermarkets in the UK operates a system which moves over 700.000.000 cases of goods each year. Because they are selling all types of goods including expensive electrical merchandise, it is important for Sainsbury to know where each case is in the supply chain. They adopted an RFID system which will be fully operationable during the next few years and it will make sure that the numbers of cases which leave one depot will be checked against the number received at the store. Theft of cases will then become impossible (AIM, 2004).

Document Tracking
Paper is still used in large scale throughout society and it is important for many firms like for example law companies, to locate and identify documents quickly. RFID tags can make this process efficient and the Vatican Library has deployed a system to identify and track books in its large collection of nearly 2 million books. With the system used today, the library has to close one month each year to go through the inventory, but with the new system based on RFID, it will only take half a day (AIM, 2004).

In the UK both the new Library in Brighton and the library at Nottingham Trent University have taken the advantage of the RFID technology. At the Nottingham University the system has helped the library to increase their opening hours where students themselves can borrow books instead of needing staff to perform this type of operation (AIM, 2004).

Security
Smart cards based on RFID are used to gain access to secure areas and buildings. The smart card has a functionality which is very flexible and it used in many application areas. Electronic tickets for local public transportation is just one of many and this can be found in major cities like for example London (Oystercard.com, 2006). Others are tickets to sporting events like football games and the World Cup 2006 which were held in Germany (AIM, 2004). The smart card has many benefits and one of them is the possibility to have multiple applications like passport, credit card and driving license can be put on a single smart card (Dhar, 2003).

The new biometrical passports which were introduced in October last year use RFID technology to verify the identity of the person carrying the passport. This is done by

placing an image of the face together with other information about the individual on an RFID tag in the passport. Other biometrical information like a fingerprint and scanning of the iris are also considered to be implemented. However there has been some dissatisfaction with the new passports, especially from the Datatilsynet, due to the reason that the privacy of the individual can be endangered (Digi.no, 2005)

A primary school in Tokyo has started using a new security system based on RFID which monitors when the pupils come and go out of the school. The time and date is recorded and makes it possible for teachers and parents to know that the child has safely arrived at school. The tags are placed on personal belongings like school bag or books (AIM, 2004).

Food Supplies
The outbreak of different illnesses like hepatitis and mad cow disease has forced the suppliers to keep better records of their food supply. In the UK they have adopted strict rules for the companies. The companies must be able to trace a package of meat in the supermarket all the way back to the animal which was slaughtered for it (AIM, 2004).

Healthcare
The healthcare sector is starting to use the RFID technology with the possibilities of increasing efficiency, but also increasing the safety of the patients (AIM, 2004). A South African company called Wavetrend Technologies has developed a system which is deployed in hospitals in Singapore. The system makes it easier for the hospitals to trace people who have been in contact with victims of SARS. Previously this job was done manually and took up to two days, but now it is done by the click of a mouse (AIM, 2004).

In the USA they estimate that the use of RFID in pharmaceutical industry may be able to prevent many of the 1.25 million adverse reactions and 7.000 deaths which occur each year and are a result of drug error (AIM, 2004).

Future
The future is looking very bright for this technology and the development is taking one step further every day. RFID has a lot of potential, but in order to take full advantage of it there are also other requirements that must be fulfilled in other areas as development of applications software, consideration of legal aspects, development of supporting infrastructure to design, install and maintain RFID systems (Landt, 2005). Soon we all may live in a world where all objects carry a RFID tag. Ari Juels (Juels, 2006) has mentioned several possibilities as for example smart appliances, shopping and medication compliance. Smart appliances could for example be a washing machine which knows how long to wash you clothes and which program to use. Your refrigerator can have an RFID tag which registers when the milk is empty or if it is expired and then automatically warns you or orders milk from the nearby store to be delivered to your door. When it comes to shopping, consumers could have the opportunity to check out the merchandise simply by taking the shopping cart past a point-of-sale terminal. The terminal will count the number of items in the

cart, sum up the total cost and maybe also charge the consumers credit card. There are ongoing research at the University of Washington and Intel which investigates the possibility of using RFID to help with medication compliance. This is done by using a medicine cabinet which is equipped with an RFID tag that helps verify if the medicines are taken in a normal manner

4.1.6 Automatic Identification and Data Collection technologies

RFID is a member of the AIDC technologies together with bar codes and magnetic stripes. These technologies date as far back as the 1930's and 1940's and magnetic stripes is the oldest one. Wire recorders and dictating machines sold from the beginning of the 1930's used magnetic stripes and today the stripes are used on debit and credit cards and stored-value cards. Cards with magnetic stripes are also used by many organizations for employee ids and tickets with magnetic stripes are used for access control on events in sports, music and theatres. During the years the only changed made on this technology is the transition from analogue to digital encoding (Rosenberg and Garfinkel, 2005).

In 1949 the first barcode patent became issued and in the 1960's a rail tracking system became the first large application of the technology. Later in the 70's efforts were made in order to make a bar code for item identification. The solution became linear bar codes which were very practical thanks to new bar code scanners. These scanners were substituted by supermarket scanners. Later on came UPC and as already mentioned, will EPC follow in near future (Rosenberg and Garfinkel, 2005).

RFID is the oldest of the AIDC technologies, but is today a modern and popular technology with many exciting application areas and yet more to come. The area of interest in this thesis is user acceptance of paper and electronic tickets. Tickets use either bar codes or magnetic stripes, but several clubs have started to deploy tickets based on RFID. Gaining access to the stadium has worked well with the two former technologies, but the point is that RFID represents many advantages compared to the other two and not just in the area of tickets, but also in areas such as retail, document tracking and security. Bar codes and magnetic stripes have a long history and are widely adopted, but the fact remains that RFID is the future among the AIDC technologies.

4.1.7 Summary

This chapter has reviewed the RFID which generally is used to describe any technology that uses radio signals to identify specific objects. RFID consists of four elements which is a tag, a reader, an antenna and a computer. The technology has existed even since the World War II where it was used to identify friends or foes. RFID is an AIDC technology together with bar codes, optical character recognition and magnetic ink character recognition. The number of applications is big which

makes it difficult to categorize them, but manufacturing, distribution and inventory, retail, document tracking, security, food supplies and healthcare are some of the application areas found today. The future is looking bright for the development of RFID, but there are also concerns about privacy and security which must be dealt with.

5 Case study

This chapter will present the Smart Stadium solution, which is developed and implemented by Fortress GB and Buysec AS., together with a review of Kristiansand stadium which has implemented some of the features of the system.

5.1 Smart Stadium

5.1.1 Fortress GB and Buysec

The Smart Stadium and Venue Solution developed by Fortress GB in UK is a complete solution based on RFID for venues and was developed in cooperation with the English football clubs Manchester City and Liverpool FC. The system was installed at Manchester stadium ahead of the 2002/2003 season and the stadium became the first in the world to be a complete RFID stadium. Fans, VIPs, guests and staff were allowed to enter the arena by using RFID cards. Fortress GB's Smart Stadium Scheme is the only stadium scheme that has ever won the prestigious Sesame Best Software Award (FortressGB.com, 2006a)

In addition to The Smart Stadium solution, Fortress has also developed a system for schools called the Smart Campus and School solution. This system improves pupil safety, increases the involvement from parents, but also offers the cashless cafeteria. The system is today used by many schools around the UK and have increased efficiencies and cut costs for the clients (FortressGB.com, 2006c)

Fortress GB have many partners and one of them is Buysec AS (Buysec.no, 2005) which is a company situated in Kongsberg. They have been working with security in computer science since 1994. Central to all of their solutions have previously been smart cards and therefore it was an easy move for them to start using contactless smart cards based on the RFID technology. Because of the early use of the Smart Stadium system in the UK, Buysec have had time to gain their own experience of the system by deliveries of the technology to a handful of Norwegian football clubs including Ålesund FK (FortressGB.com, 2006b), Sandfjord FK (Sandefjordfotball.no, 2005) and IK Start (IKStart.no, 2006). A more thorough review of Kristiansand Stadium which is the home arena of IK Start will come later in this chapter.

5.1.2 Smart Stadium (Smart FC)

Fortress GB's Smart FC solution uses a contactless smart card based on RFID and applications such as access control, loyalty, electronic money and tickets are integrated on this smart card. The whole idea behind the solution was to develop a system which can cut costs and make the stadiums run more efficiently because there is no secret that football is business and every club wants to make as large profit as possible, but at the same time offer a good service and experience to the fans. By using the system people can gain access to the stadiums at a faster pace (about 1000

an hour) than before, but also take advantage of the other offers integrated on the smart card. Fortress GB believe that by combining a better season card together with quicker access to the stadium, in addition to an easier way to shop at the arena, the fans will be encouraged to spend more money during the games on club merchandise and food (FortressGB.com, 2006d).

Every football club is different. This is the reason why Fortress GB tailors different smart card solutions to each club depending on the specific requirements they must have. The system is built up by modules which mean that a club can start with a single application and later on add other modules to build up an ideal system over time. Both the software and the hardware can integrate to existing systems and are designed to be self-managed. The smart cards used by Fortress GB are so secure that they are in compliance with standards used by banks in the UK. This means the possibility of a cashless stadium where fans can buy everything they want at the stadium by using their own smart card (FortressGB.com, 2006d).

Benefits of Smart FC:

- Ticketing
- Access control
- Loyalty schemes
- The cashless stadium
- Family cards
- Stadium Resource Management

Ticketing
The new smart season card is supposed to both replace the regular season ticket, but also tickets sold to single games. These tickets can be sold through the internet, by telephone or using the mobile phone. In addition to regular league games, it is also possible to load the card with cup games. All kinds of information like matches stand and seat information is to be found on the smart season card at the beginning of the season and the same card is used through the whole season (FortressGB.com, 2006d).

If an owner of a smart season card cannot go to a game, he/she can sell the ticket back to the club which removes the game from the card. The club in turn can sell the ticket once again to another customer and this way come closer to the ideal goal of a sold out stadium (FortressGB.com, 2006d).

Benefits with the tickets:

- Easy to carry and use
- Because the card is long lasting, yearly production costs are saved
- Impossible to forge
- Can prevent known trouble-makers to enter the stadium
- Easily replaced if lost or stolen

Access control
Smart Stadium is based on contactless smart cards which are used to gain access to the stadium. With this technology there is no need for manual ticket control or barcode readers and costs are saved by not needing people in the ticket booths. All the supporters have to do to enter the stadium is to wave the card in front of the card reader which is installed in the turnstile. The access to the stadium is made easy for the fans and cues are avoidable while security is maintained at a high level. Information about who is present at the stadium is updated real-time in the database and this gives the club a complete overview about which person entered trough which gate at what time. Unwanted persons like known trouble-makers can be prevented from entering the stadium by this system (FortressGB.com, 2006d).

The security in the smart cards makes them impossible to copy and forge which assures the authenticity of the ticket. In addition will a transition from paper tickets to smart cards remove the possibility of selling the tickets at the black market (FortressGB.com, 2006d).

Loyalty schemes
With Smart Stadium the supporters can earn loyalty points through their activities with the club. Points can be gained by buying merchandise in local shops, at the stadium or through the club's website. The smart card is automatically credited with the points and these points can be used to buy other merchandise, tickets or snacks. Card holders can view their loyalty points' balance through the internet and the point with the loyalty scheme is to stimulate the customers and the fans to spend more money. In return the supporters feel they receive value for their support for the club and this helps building a strong connection between the club and the fans (FortressGB.com, 2006d).

The cashless stadium
Fortress GB's Smart FC can cut cash-handling costs to zero, reducing theft and fraud while encouraging higher spending and achieving faster transaction times. The e-Purse application enables each card to carry e-money or a credit line. Fixed and portable smart card readers are installed at points of sale both inside and outside the ground. Supporters can use their card to pay for anything from a programme to team strips for the entire family. The card can also be used for purchases in vending machines, for video games and is also suited to betting, as electronic certificates confirming each bet is issued. When a card is lost or stolen, it can be blocked and the balance left on them can be than transferred to the new card issued (FortressGB.com, 2006d).

With the technology the Smart Stadium uses and the contactless smart cards, clubs can eliminate the need for cash at the stadium. Portable and fixed smart card readers can be installed both inside and outside of the stadium where sales can be made and with the smart card you can buy anything from a hot dog, to tickets and club scarves. When the money on the card is empty, it is easy to fill it up. When it comes to VIPs, it

is also possible for the club to send a bill if the account is overdrawn (FortressGB.com, 2006d).

Benefits with cashless stadium:

- Reduced transaction times
- Reduced theft and fraud
- Reduced cost for the management of money
- Easier for the supporters to shop tickets and merchandise

Family cards
Every smart season card can be made a parent card for several other smart cards which can be owned by children or any other close family. Loyalty points can be transferred from the parent card to the sub-cards and used in the normal way to buy merchandise or tickets. This way the parent card is in complete control of the spending made by the other cards and the parents and children don't need to go together to shop (FortressGB.com, 2006d).

Stadium Resource Management
In addition to the other modules, there exists a module which handles all the resources at the stadium during the games. Each member has a smart card which they can use to enter restricted areas and the system is in control of staff, hosts, other personnel and attendance at the stadium (FortressGB.com, 2006d).

The Smart Stadium solution has existed for several years and is found on a lot of English arenas among others Arsenal FC, West Ham FC, Manchester City and Reading FC. The results have been really good for the last three mentioned clubs. In table 5-1 you can find numbers of season holder tickets before and after the introduction of Smart Stadium.

Club (capacity)	Average attendance pre-solution	Average attendance post-solution	% Increase
Manchester City (48.000)	2002-2003 34.565	2003-2004 46.834	35.5%
West Ham United FC (35.647)	2004-2005 27.403	2005-2006 33.561	22.5%
Reading FC (24.200)	2004-2005 17.169	2005-2006 19.976	16.4%

Table 5-1: Pre- and post-solution of Smart Stadium (Wilhelmsen, 2006)

In Norway there are few clubs who are using the system today:

- IK Start
- Sandefjord Fotball

- Ålesund FK
- Viking FK
- Lillestrøm SK – The ticket system only used for VIP
- Brann SK –will start next season

The feedback from the use of Smart FC from these clubs has been very good. Sandefjord stadium and Kristiansand stadium, which I have visited during the work with this thesis, use both paper tickets and electronic tickets. This way people are given a choice and the reason for their choice was of great interest for me since the main topic of this thesis is user acceptance and why people choose paper or electronic tickets.

5.1.3 Kristiansand Stadium

At Kristiansand Stadium in Kristiansand the Smart Stadium solution was implemented last year and has been used throughout the season of 2006. Kristiansand stadium has only used the feature of electronic tickets and the smart card which is called the "Start card" as can be seen in figure 5-1, but the clubs new arena "Sør Arena" will have several features implemented. With the "Start card" it is possible to buy tickets for the whole season or single games on the internet. The card costs only 50 Norwegian crowners (NOK) and if it is lost, it can be easily replaced by a new one for another 50 NOK. Tickets for the Start card is 10 crowners cheaper than paper tickets and therefore people have an incentive to use electronic instead of paper tickets. Paper tickets can be bought both on the web and at the stadium compared to the electronic tickets which only can be found on the internet. One of the benefits of buying the season ticket is that you get your own seat for the rest of the season.

Figure 5-1: Start smart card (Martinsen, 2006a)

Since Kristiansand stadium both uses paper and electronic tickets, all entrances are equipped with RFID-readers and people to take care of the paper tickets. Figure 5-2 shows a typical entrance at Kristiansand stadium. Since there are no turnstiles present which are present at stadiums in UK where the solution is deployed, there has to be a person controlling the entrance and the RFID-reader. Otherwise people

can walk right through. By having staff by the reader, no money is saved with regards to personnel.

Figure 5-2: Typical entrance at Kristiansand stadium (Martinsen, 2006b)

To use the card you only have to put it above the club symbol of IK Start on the RFID-reader for a couple of seconds to see if it is accepted or rejected. The RFID-reader is shown in figure 5-3. A green or red light will glow with additional sound if the person is allowed to enter or not. When I first looked at the machine I had really no idea of how to use it and after observing other people for nearly an hour it was clear that the system is not easy in use even though the system has been employed for an entire season. Some of the people who faced the machine had to ask the guard standing by the machine of how to operate it and it seems the club did a wise decision to have a person by the reader. Obviously the system is not intuitive enough because it should not be necessary to explain it.

Figure 5-3: RFID-reader at Kristiansand stadium (Martinsen, 2006c)

The first season with electronic tickets has been very successful for Start with regards to number of season tickets sold this season compared to last year and this can be seen in table 5-2. The table also shows the numbers for Sandefjord Fotball which implemented the system last year like Start did.

Club	Tickets sold pre-solution	Tickets sold post-solution	% Increase
Start	2005-2006 1400	2006-2007 3700	264,3%
Sandefjord	2005-2006 900	2006-2007 2500	277,8%

Table 5-2: The number of season tickets sold before and after the introduction of Smart Stadium at Kristiansand stadium and at Sandefjord stadium (Martinsen, 2006d)

In the future IK Start wants to expand the use of the Smart Stadium system to include features like loyalty schemes and the cashless stadium, but this work is only at an early stage today. Paper tickets will still be offered, but the club is hoping for a future with only electronic tickets (personal communication with Kari Sædberg working for IK Start).

5.1.4 Summary

Smart Stadium or Smart FC is a system developed by Fortress GB in the UK and distributed in Norway by Buysec AS. It is a complete solution developed for venues and it is based on RFID. Smart FC has many benefits like ticketing, access control, loyalty schemes, the cashless stadium, family cards and stadium resource management and it is for example used on football stadiums in both UK and

Norway. IK Start is one of these Norwegian clubs and a visit was made to their home arena Kristiansand stadium to get a closer look at the system.

6 Findings

This chapter will present the results from the conducted empirical studies.

6.1 Empirical investigation

During the empirical investigation a questionnaire was made available on the internet and the link was distributed in the forums of the Norwegian clubs who employ the Smart Stadium system at their home arena. Interviews were also conducted in relation with a home game of Sandefjord Fotball and IK Start.

6.1.1 Questionnaire

6.1.1.1 Background information

A total of 201 people answered the questionnaire and from these 156 were found adequate to be used. Among the 156 respondents 90.4% were male while 9.6% were female. The majority were found in the three age categories 11-20, 21-30, 31-40 which accumulated to a total of 85.3%. The other categories were 41-50 (9.6%), 51-60 (4.5%) and 60++ (0.6%). Figure 6-1 shows there were slight differences between the respondents who have 1 or more years with higher education, but 42.3% had 0 years.

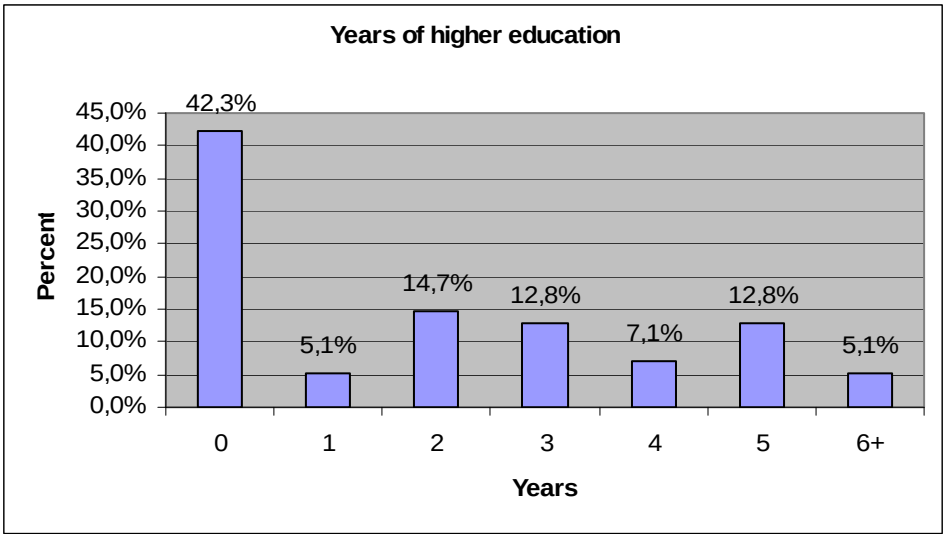

Figure 6-1: The number of years with higher education among the respondents

6.1.1.2 RFID and ubiquitous technology

To get a better impression of the respondents knowledge about RFID and the use of the technology in smart cards, a question in the survey were stated about their knowledge and also if they could mention other technologies which use RFID.

The knowledge was very limited among all the respondents, but also limited among the respondents who use electronic tickets even though these smart cards employ RFID. Figure 6-2 shows that only 19.2% knew about RFID in smart cards and 80.8% did not. One person commented "I've used the smart card for several years, but had no idea it used RFID". Another person complained about the information of the product from the club: "The information about the product should be better than it has been until now with Ålesund".

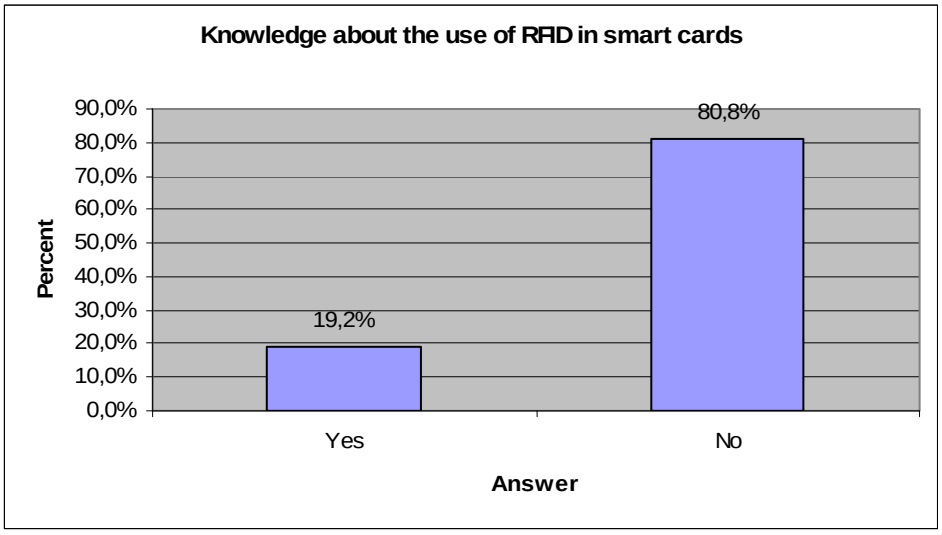

Figure 6-2: Knowledge about the use of RFID in smart cards among the respondents

Since the knowledge about RFID was so low, few additional examples were given. Among the mentioned were Autopass, container terminals, labelling of goods, RFID bracelets which were used to pay for alcohol in the bar during UKA 05 and products from Gillette. Gillette was among the first retailers to introduce RFID in their products.

There has been a lot of attention and focus on the new biometrical passports in the news, but nobody mentioned these as an example. However new VISA-cards were correctly pointed out.

A person stated: "The price of producing RFID tags are so far too high to use in large scale." This is a correct remark as we have discussed the price of the EPC tags already (chapter 4.1.4) in conjunction with privacy and security issues.

In order to get a deeper understanding about the way people feel about technology, an allegation was put forward: "Technology is supposed to make everyday life easier for most people it is claimed by some researchers

Most people agree that the claim is right, but the technology can both make the everyday life easier and difficult. It all depends on who you talk to. For a person with good skills and experience it is helpful, but it takes time to completely learn the

technology. For those who are not able of handling the new technology, the technology can seem a bit excluding. Remarks from the questionnaire:

> ”The claim surely is correct for the ones who are young and up to date.”

> “This is an allegation which is only partially correct. There is little doubt that technology in many areas has made life easier for most people. However a reasonable amount of training is needed to fully take advantage of the possibilities which technical innovations can offer. Technology can therefore be excluding if you are not able to keep up with the pace of the development.”

> ”It works as long as the need is present and it does not get too complicated for the regular citizen to understand.”

> “Technology which is established makes everyday life easier.”

Another point noted by several people is that technology can make the day more busy like for example with email. Nowadays it seems like all people have access to internet either at home, at school or at work, but it doesn't stop there. People usually have several email addresses as well for different needs and purposes and writing and sending an email is done quickly. With email everybody can reach you all the time. Not necessarily right away, but the email is there when you get home from work or back from vacation. A person commented: “Both ways. [It is] simpler in form of own queries (for example through email). [It] does also make everyday life more complicated. [We] get too available for impressions and queries. [We] use too much time on unwanted email.” Another person wrote: “It can be discussed. Everyday life is made easier, but also busier.”

A third point written by several people is that technology is good when it works, but hopeless when it collapses. We get vulnerable for technical failure as more and more equipment in hospitals, cars and airplanes are dependent on technology. Space crafts have failed to launch because of a minor technical failure and airplanes have crashed. One person remarked: “The danger is when the systems break down. Then we are helpless.” Another comment was: “Yes, but we get more vulnerable for technical failures.” Yet another: “[We are] not safe because technology that doesn't work and then causes chaos, queues and etc. Many have bad backup routines and what is the point with technology if one has to have double backup?”

A fourth point suggests that people use technology for keeping touch with family and friends when they are not living in the same city or maybe in the same country. Instant messaging and IP telephones have made it easier and cheaper to call and talk to people anywhere in the world. A respondent wrote: “Of course technology makes everyday life easier. Just look at how family members communicated with each other 50 years ago when somebody had moved far away. Today we can see them “live” on the cellphone and talk to them for a cheap price.”

6.1.1.3 Visible versus invisible technology

It was only the persons who answered they usually buy electronic tickets who answered the question about their view of the smart card as visible or invisible technology. In table 6-1 we can see it was a divided result.

Visible	Invisible	Total
26	32	58

Table 6-1: Number of respondents who think the technology is visible or invisible

The respondents were asked why they feel the smart card is visible or invisible technology and the reasons were several.

The smart card is just a regular card as can be seen on figure 5-1 with name of the holder and some other personal information. What is in the card is not visible and this is the reason why some feel the technology is invisible. "Invisible. [You] can not see the information in the card" one person thought. This statement was also supported by others.

People are used to having the paper ticket in the hand when they enter the stadium. The Smart FC system has only been in use for a few seasons in Norway and many people think of the smart card only as a ticket and not as technology. One person stated: "Invisible. [I] never think of it as technology, only as a ticket". Another wrote: "[I] never go around and think about the card. This is only something you use now and then."

The notion of routine goes together with the notion of invisible and visible technology. A couple of persons feel the technology is invisible because it used on a routine basis. These respondents watch many games per month and use the card often. Another respondent did not agree with their view and felt the technology was visible even though the use of the card is routine. He argued that the card is not used by itself, but has to be employed explicitly by an individual. Routine will be more reviewed later in this chapter

The most common argument given by the respondents was that the technology is visible because the card is physical, can be seen and has to be used explicitly by placing it on the RFID reader to enter the stadium. Some argue that they are consciously aware that the card is in the wallet and need to be brought to the game to gain access and therefore the card is visible technology. A remark made: "Visible. It is a physical card."

6.1.1.4 Unremarkable routine

The question about considered use of smart card was only answered by people who use and buy electronic tickets and figure 6-3 shows that the use is mainly considered as a routine.

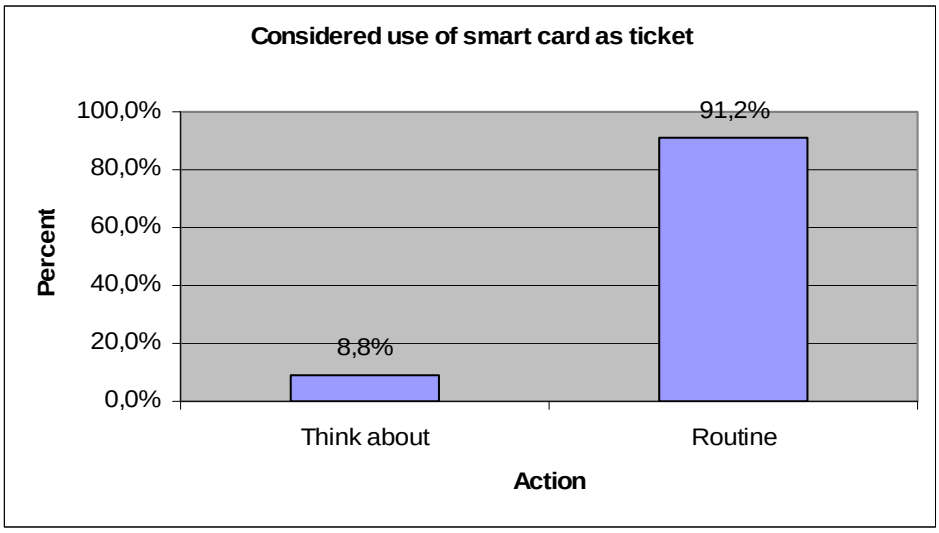

Figure 6-3: Answer to the question whether the use of the smart card is routine or something to think about

In addition the respondents were asked to describe how it is to use the card as a ticket to gain access to the stadium. Everybody feels it is a great and easy way to get into the stadium. Nobody is actually complaining about the use and this is the way the system is supposed to work, but my observations showed some difficulties in operating the system which were caused by not knowing where to put the smart card on the RFID-reader (chapter 5.1.3). Comments given were: "Much smarter", "Very easy", "Easier it can not be done" and "Fast and easy".

6.1.1.5 Centre versus periphery of attention

It is most common that the card have full attention before going to the game or just before entering the arena because this is the only time the card is really needed. Otherwise the card can be put in a safe place until the next time it is going to be used.

Another answer, but not so common is when using money or paying for something. Loading the smart card with tickets of course costs money and whether buying the tickets or not is a decision which demands consideration. One respondent commented: "[The card] has full attention when I am paying".

One person wrote that the card has full attention all the time and another when she can not find it. This seems very reasonable as it can be stressful to not be in control.

It is common among the people to check for the card when they are going to a game or when they are going to use it. Some check too see if the card is in the wallet before

leaving home while others usually carry it in their wallet and only check for the card just before entering the ticket arena where the RFID-reader is located. Two comments support this: "[I] check before the game" and "I check that the card is in the wallet before I go to the game, but never think about it otherwise".

Others check to see if the card is there on a normal day, but it may also be observed in the wallet while looking for other cards like the credit card or the gasoline card. Of the responses it seems common to look for cards from time to time just to be certain that they are present. "Do not think about it usually, but only observe it in the wallet from time to time when looking for other cards."

6.1.1.6 User acceptance and adopter categories

Even after a couple of seasons with electronic tickets, the paper ticket is still the preferred choice at least among the respondents in my survey. Of the 156 who answered the survey, 57.1% buy paper tickets as can be seen in figure 6-4. This number will probably fall in the forthcoming years when the clubs start using new stadiums which use more of the features available with Smart FC.

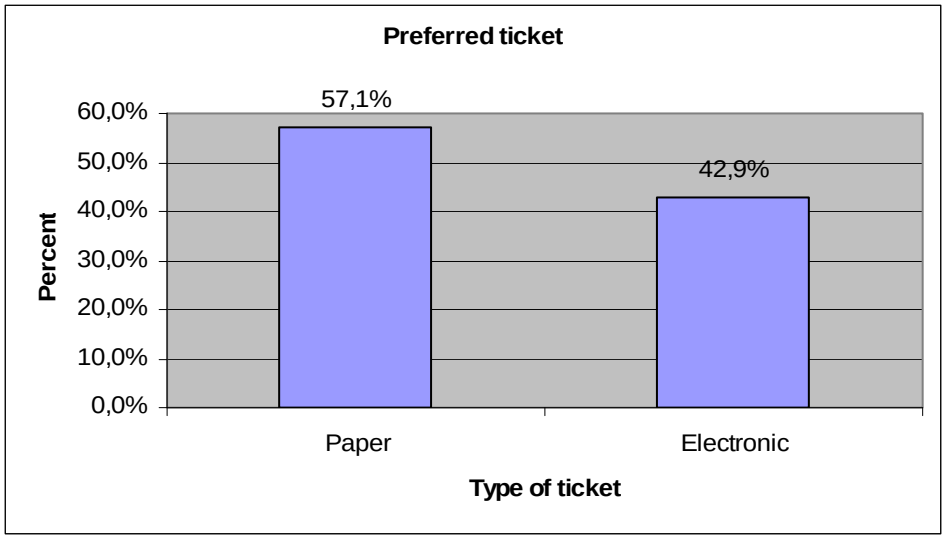

Figure 6-4: Type of ticket preferred between paper and electronic

There are many reasons given from both the ones who buy electronic and from the ones who buy paper tickets. Simple and practical are two descriptions provided by both sides, but others are much more specific for the type of ticket bought. Benefits with buying electronic tickets are identified by the respondents and time saved by avoiding queues and not needing to collect the ticket are the two most mentioned. Another benefit with electronic tickets is that you get your own seat for the entire season and you are first in line for buying tickets to other games such as the national cup and tournaments in Europe as well. In addition you are first in line for the seat also next season when the season tickets are put out for sale. However when you buy paper tickets you can not have the same seat from game to game, but have to pick

whatever is available. If you buy paper tickets on the internet, it is possible to choose a seat, but when you buy at the stadium, one is selected for you. A person who buys electronic tickets commented:

> "You don't have to think about collecting the ticket, just load it on the smart card when you buy and the card is with you anyway. A paper ticket disappears easier. I noticed it was easier going to game when we received the smart card instead of 13 single paper tickets".

Some of the comments from the buyers of paper tickets indicate fear of technology. One person wrote: "Because then I have the ticket in my hand and know that I do not end up in a situation where the card does not work etc… ". Another wrote: "Easiest and because it is so much wrong with the electronic tickets". Other remarks point out the tradition and habit for buying paper tickets. People are creatures of habit and it is easy to stay with one choice even though another one is simpler and more efficient.

"Did not know of any other type of ticket" was commented from some people. If the club does not actively go out and inform about electronic tickets and the ease of use, the buyers do not have the possibility to consider the different options and make a decision. Table 6-2 shows how many years the respondents who buy electronic tickets have employed the smart card. The numbers show that the system is very new in Norway.

1 year	2 years	3 years	Total
20	32	6	58

Table 6-2: Number of years using the smart card among the respondents who buy electronic tickets

Another question about the use of smart card was asked in the questionnaire. This was in relation with user acceptance because it can be easier to persuade users to utilize a new technology or innovation if it can be tried first. Only 14.7% of the respondents, as can be seen in figure 6-5, had the opportunity to try the smart card before Smart FC was implemented at the stadium.

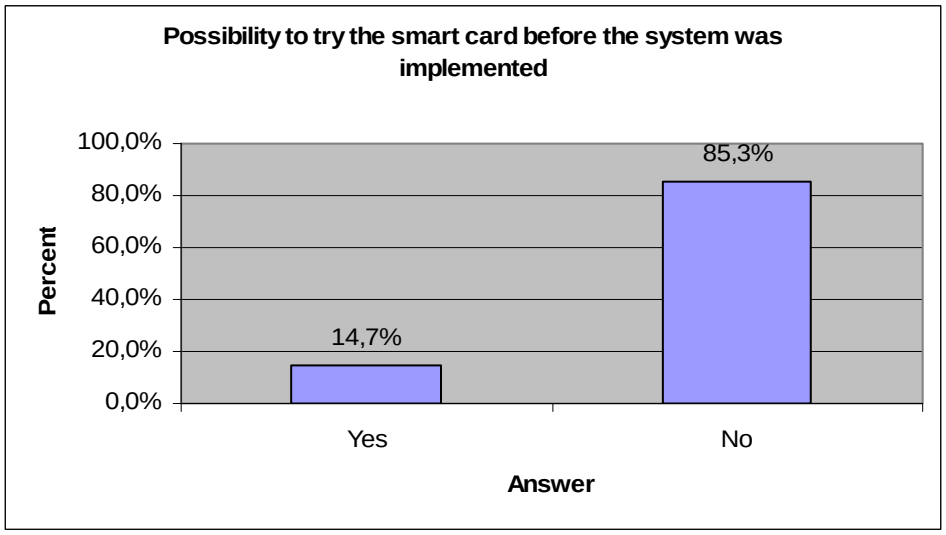

Figure 6-5: Number of respondents who had the opportunity of trying the smart card before the system was put into use at the stadium

The last question in relation with user acceptance and adopter categories was a large one with several minor topics like exposure to media, travel, opinions, social network and how the respondents characterise themselves in terms of taking use of new technology. These topics are a part of the categorization of adopters by Rogers and were needed in order to help categorise the respondents. Figure 6-6 shows the results. As many as 35.9% of the respondents described themselves as venturesome and deliberate while 23.1% answered respect. Only 3.8% answered sceptical and 1.3% traditional.

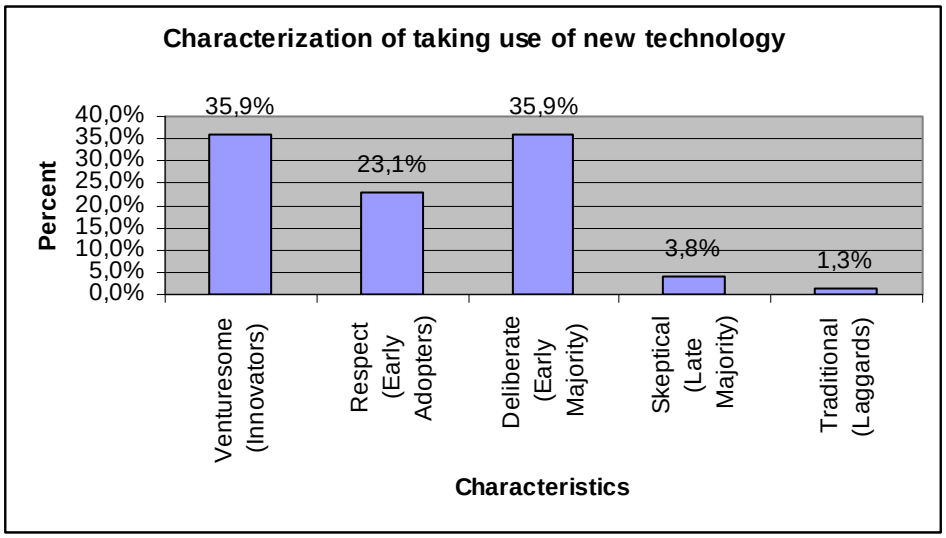

Figure 6-6: How the users describe themselves in taking use of new technology with the adopter categories in parenthesis

6.1.2 Interviews

The interviews were mainly concerned with the preferred choice of ticket and as the reason behind the choice, but other topics like unremarkable routine and visible/invisible technology were touched as well.

Many people buy season tickets just to be sure to catch every home game of the season. They do not care whether the tickets are paper or electronic. They just want the season ticket.

A family I spoke to bought paper tickets this time, but prefer electronic ticket next season. This is because it is much simpler they said. The family had experienced this from others also. It seems influence by others counts in making a choice in the family I spoke to.

Several of the interviewed simply can not afford to buy season tickets even if the season ticket is cheaper and more flexible, but has to buy single tickets instead. With the Start card it is possible to charge the card on the internet with tickets for games. Many people think it is an excellent solution since they prefer the electronic ticket because of its ease of use. In addition are electronic tickets 10 NOK cheaper than paper tickets and therefore people have an incentive to buy electronic tickets on the internet.

Some people I interviewed preferred to have the ticket in the hand like the old and usual way instead of just one card. Many of these had not heard of RFID and seemed to be sceptical to new technology and especially since the technology in large seemed invisible. However many felt technology made everyday life easier and television, communication and internet were mentioned as proofs of this. Most people felt the smart card is invisible because the information is hidden, but said the card becomes visible when problems occur with the card when reading it at the scanner at the entrance.

6.1.3 Summary

This chapter showed the results from the questionnaire and the interviews conducted. The main focus was on the preferred choice of ticket and the reason behind this choice and the majority of the respondents still buy paper tickets. Many reasons for buying either electronic or paper tickets were given in the questionnaire and the interviews yielded many of the same.

7 Discussion

This chapter will repeat and discuss the problem definitions introduced in chapter 1.5. In order to discuss the research questions, theory and concepts from chapter 3 will be used together with the findings from the empirical investigation which were presented in chapter 6. The research questions concern user acceptance of tickets, adopter categorization of users and the perceived attribute of complexity which deals with the ease of use and the understanding of technology.

7.1 User acceptance of tickets

The first research question was:

What is the preferred choice of ticket today between the paper and the RFID-based electronic ticket and what are the reasons for this choice?

The preferred choice of ticket among the 156 respondents in the survey when attending a football game was the paper ticket. As figure 6-4 shows, 57.7% choose paper ticket and 42.3% the electronic alternative. Paper is still the most popular ticket even though the Smart Stadium system and electronic tickets have been employed for 1-3 years depending on the club and stadium. The five clubs which use electronic tickets today are IK Start, Sandefjord Fotball, Ålesund FK, Viking FK, Lillestrøm SK while Brann SK will start the forthcoming season. IK Start and Kristiansand stadium which was reviewed closely in the case study (chapter 5.1.3), use an optional innovation-decision where the individual is free to adopt or reject an innovation. The spectators can chose to either buy electronic tickets on the internet with the Start smart card or buy regular paper tickets on the internet or at the stadium. With IK Start's new arena all the seats at the stadium are available as season tickets. In the near future the board wants to offer electronic tickets only. This type of decision is called authority innovation-decision where the choice to adopt or reject is made by a few number of individuals or leaders of an organization. For the time being Sandefjord Fotball, Viking FK and Ålesund FK also use optional innovation-decision where the fans are able to buy paper based tickets on the internet while the electronic smart cards are reserved for holders of season tickets.

Several reasons for their choice of ticket were given by the respondents on the questionnaire and the people who were interviewed, but some were remarked more often than others. With regards to the paper tickets, many people commented that they prefer to have the ticket in the hand such that the ticket is visible. The cause for this was mainly fear that the electronic ticket will not work as it should do when using it at the RFID-reader at the entrance to the stadium. By making this comment, it seems these people are skeptical to technology and especially new technology and instead prefer the traditional choice of paper tickets.

Secondly the buyer of paper tickets point out the tradition for purchasing these. Until recently paper has been the only option to gain access to the stadium when going to football games in Norway. Electronic tickets on the other hand are a fairly new technology seen with Norwegian eyes. As written in Leonardo's Laptop

(Shneiderman, 2002): "Most users are not interested in the technology; they are focused on their own information needs and relationships." This comes in relation with the third argument for buying paper tickets. Many people did not know of another option besides the paper ticket. Lack of information from the club about the product is one of the reasons mentioned by the respondents. When you do not have the knowledge of alternatives it is common sense to choose the option you have tradition and habit for choosing and which has always worked as expected, namely paper tickets. Data from the interviews also support the fact that people do not care about the ticket just as long as they are able to come in and watch the game.

The buyers of electronic tickets however recognize the benefits and give these as reasons for their choice. One of the gains with electronic tickets is time saved by avoiding queues when entering the stadium. When using paper tickets, you have to give the paper ticket to a member of staff at the gate who has to check if the ticket is valid, if it is a ticket for the right part of arena and if it is a ticket for the right section of the tribune. If all these are correct, the person tears off a part of the ticket and returns the rest. Meanwhile with the electronic ticket, the ticket holder can go up to the RFID-reader and hold the card above the club emblem for a couple of seconds. The card is then checked against all the same points as mentioned with the paper ticket. If the ticket is valid for the match, a green light will glow on the reader. Otherwise a red light will show together with a sound indicating that the ticket holder can not enter. This is a much faster and easier way to enter the arena than with a paper ticket and the queues will dissolve more quickly. Trials done in England show that nearly 1000 people can enter a gate in an hour.

Another benefit with the electronic ticket is the time saved by not needing to pick up the ticket ahead of the game. When you have a smart card like the Start card which is used for season tickets and single games, the card is loaded with all the games you as ticket holder are allowed to see. Season ticket holders only have to buy their Start card at the beginning of the season to watch all the home games and the card is sent to the owner by mail. Owners of the Start card who are not season ticket holders can load the card with whatever game they want to attend just by loading it and paying for the ticket on the internet. The holders can choose where to sit among the available seats too. Buyers of paper tickets have several alternatives. They can either order at the internet, order by phone or buy at the stadium. Either way, they have to pick up the ticket in front of the game and can not always choose where to sit. If the ticket is bought at the arena, the best available seat is chosen. Holders of the Start card can on the other hand arrive at what time they please and know that the preferred seat is available and ready to be used. Season ticket holders at Sandefjord's home arena Storstadion even have their own name on the seats which gives a feeling of ownership.

A third advantage with the electronic ticket is the option to be first in line for additional games during the season like for example European cups or Norwegian cup games. The holders are first in line for ordering tickets for next season as well as receiving other attractive offers.

7.1.1 Summary

The results from the questionnaire showed that the paper ticket is the preferred choice of ticket today when people are attending a football game at a stadium which employs the Smart Stadium system. Buyers of paper tickets give tradition and the preference for having the ticket in the hand as reasons for their choice of ticket while buyers of electronic tickets remark the time saved by avoiding queues and not needing to pick up the ticket ahead of the game.

7.2 Adopter categorization

The second research question was:

Categorize the respondents of the questionnaire after the model of adopter categorization developed by Everett Rogers.

From the comments and remarks made by buyers of papers and electronic tickets, it is easy to elicit characteristics of the persons which are typical for the different adopter categories as defined by Rogers. Fear and skepticality are two keywords already mentioned in conjunction with buyers of paper tickets. These two characteristics are typical for laggards and late majority which are described by Rogers as sceptical and cautious. In addition do the laggards use the past as a reference and this correlates well with the remark about the tradition and habit for buying paper tickets. In figure 7-1 the respondents of the survey are categorized into adopter categories after the model of Rogers.

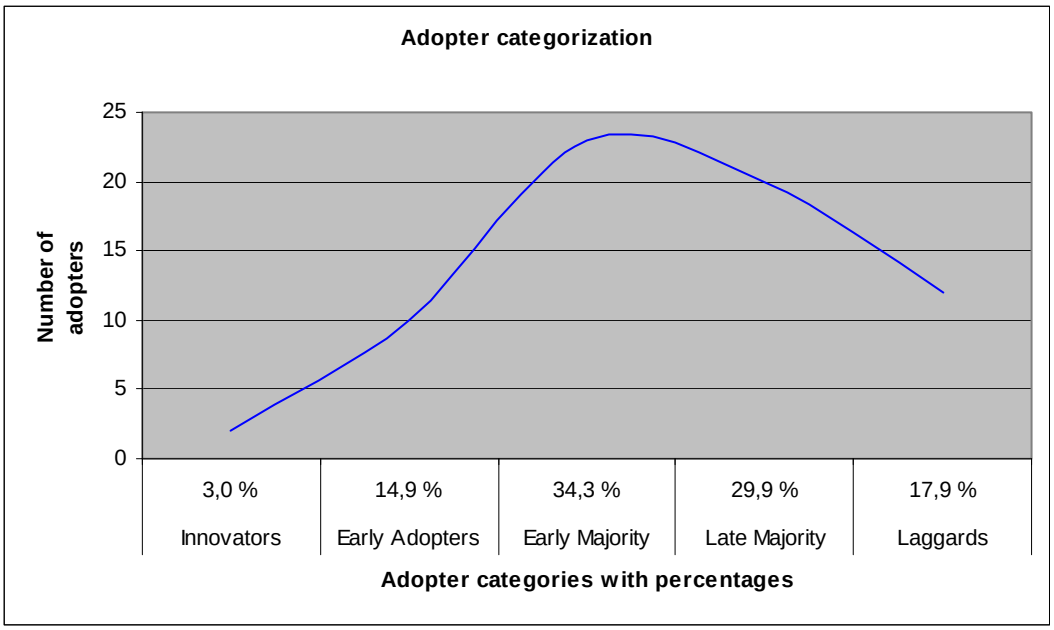

Figure 7-1: Categorization of the respondents from the questionnaire into adopter categories

Typical for innovators and early adopters is the ability to have a high ability of technical knowledge and recognize benefits with new technology and these characteristics was found in the answers from the respondents who buy electronic tickets.

The result of the adopter categorization has slight deviations from the adopter categorization by Rogers as can be seen in figure 3-3. For example laggards differ by 1.9% while innovators differ as little as 0.5%. For the other categories as well there are small differences. The three categories innovators, early adopters and early majority all are larger in percentage than the same categories in Roger's model. One reason for this may be that the world is more modern today than when this model was developed. People are living closer to each other and with all the technology that exists it is easier to keep in touch with friends, family and colleagues. In addition do people have greater access to media like newspapers, television and internet. In other words people are more exposed to media. Yet another reason may be that higher education is seen as an important step to obtain the job you really want. It is easier now than in the past to take higher education and several people take advantage of this opportunity. A fourth reason may be that people are changing habits for living. More people are today moving into the big cities and thereby becoming less localite and more cosmopolite which is another variable used to calculate the adopter categories. The different variables which were used to calculate the adopter categories were knowledge about RFID, years of higher education, exposure to media, cosmopolite/localite, opinion leadership, advance seeking and interpersonal communication. Different questions in the questionnaire were related to the different variables. How the adopter categories were calculated can be seen in Appendix II.

7.2.1 Summary

Categorization of the respondents from the questionnaire was performed after the model of Rogers and a comparison of the two adopter categorizations showed small differences. The differences are caused by the different variables like for example media exposure and higher education which are the basis for calculating the adopter categories. Possible explanations for the differences in the variables were given.

7.3 Perceived attribute of complexity

The third research question was:

Discuss the perceived attribute of complexity by using concepts from Ubiquitous computing and related theories.

All new innovations can be classified somewhere along the simplicity-complexity continuum and the simpler the innovation is perceived, the better it is. Complexity is negatively related to its rate of adoption (Rogers, 2003). To discuss the ease of use of

the innovation of the electronic ticket, the concepts which were introduced in chapter 4.1 will be used.

Findings from the questionnaire show that the respondents do not usually think about the smart card when it is not being used. It is most common that the card have full attention before going to the game or just before entering the arena because this is the only time the card is really needed. Otherwise the card can be put in a safe place until the next time it is going to be used. This finding is in accordance with Weiser and Brown's vision of Calm Computing where in one moment something can be in the periphery while in the next it is in the focus of our attention. The smart card is in the periphery of the holder's attention when it is not being used and in the centre of attention when leaving home to go to the game. The smart card is also in the centre of attention when the holder is about to load the card with a ticket and when the user is not in control of the card, but needs to look for it.

Weiser said that a good tool is an invisible tool, but the findings can not fully support this claim because the respondents were divided in their experience of the use of the card. There were mainly two arguments which divided the group of users. The part of the group who thought the smart card was invisible argued that the information in the card is not visible. An RFID-tag with information is embedded in the card, but neither the tag nor the information is visible. The information becomes visible for the supervisors of the system who can observe which person enters which gate and at what time. For the regular user it is just a regular card. However, the other part of the group argued that the technology is visible because the card is physical, has information written on it and it has to be used explicitly. Some of the users in this group remarked that they are consciously aware of the card and the technology. This does not fit with Weiser's vision to make the technology invisible to the users nor Hiroshi and Brygg's concept of technology in the background. In addition the finding does not fit with AmI which is deployed to make computers and technology disappear in the background and move into the periphery of attention

Routine invisibility or unremarkable routine use was discovered by Tolmie *et al* (Tolmie et al., 2002) in their studies about routines. Routine invisibility or invisibility in use occurs when a person performs a task on a regular basis and thereby it becomes routine and invisible for the person. Findings from the survey support Tolmie's concept of unremarkable routine. Almost all of the respondents who use the smart card feel the use is routine. People remarked that the technology is invisible because it is used on a routine basis. These respondents watch many games per month and use the card often.

The perceived attribute of complexity is loosely described in IDT. The definition is clear and precise, but no explanation on how to discuss the ease of use and understanding are given. The concepts from Ubiquitous computing and the different theories like Calm computing, Unremarkable computing, Tangible computing and Ambient intelligence could be used to shed more light on the complexity of an innovation. Concepts like unremarkable routine, centre and periphery of attention

and invisibility/visibility in use can all be employed in the discussion of ease of use which the complexity is about. Critics have been raised against the loose descriptions of the five perceived attributes of an innovation given by Rogers, but with the concepts just mentioned and used in this discussion, at least the description of one attribute could be better understood.

7.3.1 Summary

Complexity is one of the five perceived attributes of an innovation defined by Rogers and it concerns the ease of use of an innovation. There are claims that the attributes are too loosely described, but concepts like unremarkable routine and centre and periphery of attention can enlighten the attribute of complexity and make this better described.

7.4 Summary

We have seen what the user acceptance is for electronic and paper tickets today and discussed reasons for the preferred choice of ticket among the respondents. The users from the questionnaire were categorized after the adopter categories defined by Rogers and the perceived attribute of complexity of an innovation was discussed in relation with the electronic ticket and concepts from Ubiquitous computing and related theories.

8 Conclusions

In this chapter I will conclude the thesis by bringing forward the research questions from the chapter of introduction and explain which research methods were used in order to answer these. Suggestions for further work will be given as well to encourage other researchers to explore the research area of user acceptance and diffusion of innovation theory in relation with tickets even further.

8.1 Conclusion

In this thesis I conducted a research on the user acceptance of electronic and paper tickets as well as the Smart Stadium system which is used at different football stadiums in Norway. The aim was to discover the preferred choice of ticket along with the reasons for their choice among the people who attend football games at stadiums using the Smart Stadium system. The other two research questions were:

- Categorize the respondents of the questionnaire after the model of adopter categorization developed by Everett Rogers.
- Discuss the perceived attribute of complexity by using concepts from Ubiquitous computing and related theories.

In order to explore these issues and get insight, a case study and a survey were conducted. A total number of 156 people answered the questionnaire which had both qualitative and quantitative questions. The responses on the quantitative questions were used to make graphs and figures and in large answer the main problem of this thesis, but also to calculate the adopter categories in order to answer the second research question. Meanwhile answers on the qualitative questions were used to discuss the reasons for people's preferred choice of ticket as well as discussing the perceived attribute of complexity. Interviews and observations were in addition used to shed light both on the first and the last research question.

The empirical studies show that paper tickets still have the highest user acceptance even though the RFID-based electronic ticket has been used for up till three years at several football stadiums in Norway. Electronic tickets have the advantage of avoiding queues at the stadium and not needing to pick up the ticket ahead of the game. These are the main reasons for choosing this type of ticket given by buyers. Buyers of paper tickets on the other hand give tradition for purchasing this type of ticket as well as the preference for holding the ticket physically visible in the hand as main reasons for their choice.

The categorization of the respondents from the questionnaire into adopter categories after the model developed by Rogers show that more people belong to the groups of innovators, early adopters and early majority than compared to the original model. The reasons for this development are due to the different variables like higher education, cosmopolite and media exposure. The world has become more modern than at the time when the model was developed and people have easier access to

media, more people are moving from the suburbs into the cities and more people take higher education.

Rogers has described five perceived attributes of an innovation and one of these is complexity which deals with ease of use. The innovation in this thesis has been the RFID-based electronic ticket and how users perceive and experience this technology has been discussed by using concepts from Ubiquitous computing and related theories as Calm computing, Ambient Intelligence, Tangible computing and Unremarkable computing. Unremarkable routine, centre and periphery of attention, technology in the background and the foreground and visibility and invisibility in use are concepts which can be used to describe the attribute complexity in more detail and make it better understood because critics have been raised against too loosely defined attributes.

8.2 Further work

It will be interesting to watch the development of football stadiums in Norway to see how many will start using electronic tickets and the Smart Stadium system which have proven to be very popular in England. Six Norwegian clubs are already using it or are on the verge of using it and if the results continue to be positive, there are good chances that even more clubs will take advantage of the technology. After some years it may be possible to check the adoption of the innovation against the S-shaped curve of adoption which was first presented by Gabriel Tarde.

It can also be interesting to conduct a survey in some years time where the users are asked about the preferred choice of ticket to find out how many users would pick paper ticket instead of electronic tickets then. This way the result of this thesis can be evaluated more closely.

List of Acronyms

RFID	-	Radio Frequency Identification
HCI	-	Human-Computer Interaction
GUI	-	Graphical User Interface
WIMP	-	Windows, icons, menus and pointers
TUI	-	Tangible User Interfaces
AmI	-	Ambient Intelligence
IDT	-	Innovation of Diffusion theory
EAS	-	Electronic Article Surveillance
AIDC	-	Automatic Identification and Data Collection
UPC	-	Universal Product Code
EPC	-	Electronic Product Code
DoD	-	U.S. Department of Defence
IS	-	Information Systems

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Appendix I: Questionnaire

Velkommen og takk for at du tok turen innom. Bakgrunnen for denne undersøkelsen er i hovedsak å undersøke brukeraksept av papirbilletter i forhold til elektroniske billetter ved fotballarenaer og finne ut hvorfor noen velger å kjøpe papirbilletter mens andre foretrekker elektroniske. Undersøkelsen tar kort tid og er selvfølgelig helt anonym. Jeg vil takke så mye på forhånd for din deltakelse. Hvis det skulle være noen spørsmål, send meg en mail.

1. Kjønn
   - Mann
   - Kvinne

2. Alder
Hvor gammel er du?

3. Utdannelse
Hvor mange år med høyere utdannelse har du?

4. Hjemsted
I hvilken by/tettsted bor du?

5. Billettype
Hvilken type billett kjøper du vanligvis til kampene?
   - Papir
   - Elektronisk

6. Årsak til kjøp av billett
Hvorfor kjøper du denne typen billett?

7. RFID (Radio Frequency Identification)
   a. Visste du at teknologien som blir brukt i smartkortene er RFID?
      - Ja
      - Nei

   b. Kan du nevne et par andre typer teknologi som bruker RFID?

   c. Hvilken stadion ser du vanligvis kampene på?
      - Color Line Stadion
      - Viking Stadion
      - Storstadion
      - Kristiansand Stadion

   d. Hvor mange kamper i måneden går du for å se på?
      - 0

- 1-2
- 3-4
- 5-6
- Flere

Hvis du vanligvis kjøper papirbillett, hopp til spørsmål 12.

8. Rutiner
   a. Når du bruker smartkortet som billett for å komme deg inn på stadion, er dette noe du tenker videre over eller betrakter du det som en rutine?
      1. Tenker over
      2. Rutine

   b. Hvordan vil du beskrive det å bruke kortet som en billett for å komme deg inn på stadion?

9. Sentrum/periferi for oppmerksomhet

Noen forskere snakker om teknologi som beveger seg mellom sentrum for din oppmerksomhet og periferien.

   a. Nå har smartkortet din fulle oppmerksomhet?
   b. Er tankene dine helt fri fra smartkortet når du ikke bruker det, eller hender det at plutselig sjekker hvor kortet er for sikkerhetsskyld?

10. Usynlig/synlig teknologi

Noen forskere mener at "synlig" teknologi er teknologi som vi er bevisste på eller tenker over at er der, og at "usynlig" teknologi er det som er rundt oss, men som vi ikke legger merke til.

Ville du kalt smartkortet for usynlig eller synlig teknologi? Hvorfor?

11. Smartkortet
   a. Hvor lenge har du brukt smartkortet som billett?
   b. Hvordan vil du beskrive det å bruke kortet som en billett for å komme deg inn på stadion?
   c. Hadde du mulighet til å prøve ut smartkortet før du tok det i bruk?
      - Ja
      - Nei

12. Teknologi

Teknologi skal gjøre hverdagen lettere for folk flest blir det hevdet av noen forskere.

a. Hva synes du om denne påstanden?
b. Hvilke gjøremål hjelper teknologi deg med i hverdagen? Et par eksempler holder.

13. Innovasjon
a. Media

I. Hvor mange aviser leser du om dagen?
- 0
- 1-2
- 3-4
- 5-6
- Flere

II. Hvor mange dager i uken ser du på tv?
- 0
- 1-2
- 3-4
- 5-6
- Alle

III. Hvor mange bøker leser du i måneden?
- 0
- 1-2
- 3-4
- 5-6
- Flere

IV. Hvor mange dager i uken bruker du internett?
- 0
- 1-2
- 3-4
- 5-6
- Alle

b. Reise

I. Hvor ofte reiser du utenlands i løpet av året?
- 0
- 1-2
- 3-4

- 5-6
- Flere

II. Trives du best med å reise utenlands eller innenlands?
- Utenlands
- Innenlands

c. Meninger

I. Føler du at du lett lar deg påvirke av andre?
- Ja
- Nei

II. Tror du folk oftere kommer til deg for råd enn andre mennesker?
- Ja
- Nei

III. Føler du at du ofte spør andre mennesker om råd?
- Ja
- Nei

d. Sosialt nettverk

I. Hva stort sosialt nettverk føler du at du har?
- Lite
- Middels
- Stort

e. Teknologi

I forhold til å ta i bruk ny teknologi, hvordan vil du beskrive deg selv?
- Modig
- Respektfull
- Gjennomtenkt
- Skeptisk
- Tradisjonell

Appendix II: Calculation of the adopter categories

The different questions in the questionnaire which were used to calculate the adopter categories were:

- Which kind of ticket used and the knowledge about the use of RFID in the electronic ticket:

Knowledge of RFID/Type of ticket	Electronic
Yes	4 points
No	8 points

- How many years with higher education:

Years	Points
0	6
1	5
2	4
3	3
4	2
5	2
6+	1

- Exposure to media:

How many papers do you read every day?

Alternatives	Points
0	5
1-2	4
3-4	3
4-5	2
More	1

How many days a week do you watch television?

Alternatives	Points
0	5
1-2	4
3-4	3
4-5	2
All	1

How many books do you read each month?

Alternatives	Points
0	5
1-2	4
3-4	3
4-5	2
More	1

How many days per week do you use internet?

Alternatives	Points
0	5
1-2	4
3-4	3
4-5	2
All	1

- Cosmopolite/localite:

How often do you travel abroad?

Alternatives	Points
0	5
1-2	4
3-4	3
4-5	2
More	1

Do you prefer to travel abroad or domestic?

Abroad	Domestic
1 point	3 points

- Opinion leadership and advice seeking:

Do you feel that you are easily influenced by other people:

Yes	No
3 points	1 point

Do you think people often come to you for advice instead of other people?

Yes	No
1 point	3 points

Do you feel you often ask other people for advice?

Yes	No
3 points	1 point

- Interpersonal communication:

How large social network do you have?

Small	Medium	Large
5 points	3 points	1 point

It was possible to gain a total score of 55 points. All the points to the 67 respondents who use electronic tickets and the average and standard deviation were calculated:

Average (avg): 34.10 points
Standard deviation (sd): 3,71 points

How the different categories were calculated, points and percentage for each category are show beneath.

Category	Calculation
Innovators	Avg - 2sd
Early Adopters	
Early Adopters	Avg - sd
Early Majority	
Early Majority	Avg
Late Majority	
Late Majority	Avg +sd
Laggards	

Category	Points	Percentage
Innovators	0 – 27	2,99 %
Early Adopters	27 – 31	14,93%
Early Majority	31 – 35	34,33%
Late Majority	35 – 38	29,85%
Laggards	38 - 55	17,91%